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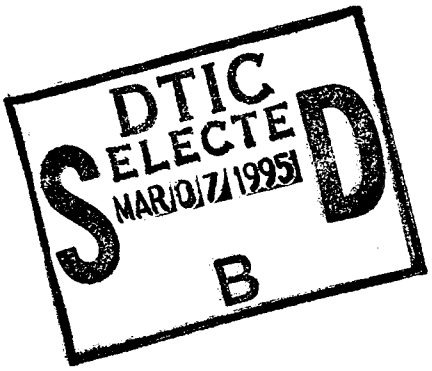
AN ANALYSIS OF ANTHROPOMETRIC DIFFERENCES AMONG OCCUPATIONAL GROUPS IN THE U.S. ARMY

by

Thomas M. Greiner, Claire C. Gordon, and Elizabeth A. Carson



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This report addresses the design relevance of anthropometric differences among occupation groups in the U.S. Army. The analysis is based upon the examination of 15 body dimensions of Army enlisted men and women within 10 broadly defined occupation groups (Career Management Fields or CMFs). The membership of each occupation group comprises unique age, race, and sex proportions. Statistical analyses (ANOVA) show that observed differences among CMFs were most strongly associated with these demographic proportions. Still, observable anthropometric differences among groups were very small. Clothing and equipment designs would have to be extremely sensitive to be influences by these differences. These findings suggest that the anthropometric relationships among CMFs may change as the demographic proportions of the Army population change. Thus, it appears that clothing and equipment designers should be more concerned with the impact of anthropometric differences due to race and sex than to the differences among occupation groups.

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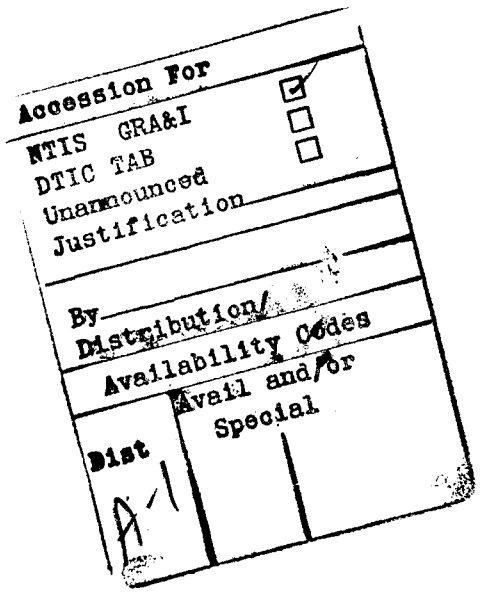

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PREFACE

This study to investigate and evaluate anthropometric differences among occupation groups in the U.S. Army was undertaken during the period December 1991 - July 1992. The funding was Project OMA, Program Element 728012.12, and Work Unit OMA 1181.

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1. INTRODUCTION

The Army is bioculturally diverse. Its membership stems from the majority of racial and cultural groups that make up the United States population. One challenge presented by the Army population is to find anthropometric order within this diversity. Clothing and individual equipment designers require this information to equip their users properly. Simple anthropometric information of current Army population means and ranges are available (see Gordon et al., 1989), yet these values describe the population as a whole. The Army comprises many important subgroups, each of which may have special clothing and equipment requirements. Designers need to know if, and how, these subgroups differ in their anthropometric characteristics. Occupational divisions within the Army form an example of such potentially important subgroups.

Anthropometric differences among occupation groups may arise from many sources. For some occupations (e.g., Law Enforcement) the Army has laid out explicit anthropometric requirements for membership (AR 611-201). Similarly, the Army prohibits female participation in certain combat-related occupations. It is not surprising that these groups are anthropometrically distinct, and designers should already be aware of these regulations. Still, many other mechanisms may produce anthropometric differences among occupation groups. For example, explicit educational requirements may tacitly discriminate against members of culturally disadvantaged groups. Lasker and Mascie-Taylor (1989) find that cultural perceptions may contribute to channeling persons into occupations based upon their stature or weight. Occupations associated with extreme physical activities may be subject to a self-selection by individuals who want either to avoid or to seek arduous labor (Hooton, 1948; 1959). Finally, training or physical activity levels within different occupations may, in part, shape the anthropometric characteristics of a group (Vogel et al., 1980). The combination of these mechanisms supports a suspicion that Army occupational groups may be anthropometrically distinct. The aim of this report is to investigate and evaluate that suspicion.

Available anthropometric data are not suited for an investigation of mechanisms that may differentiate occupational groups. Therefore, the conservative approach is to assume that those mechanisms are occurring and will continue to occur into the future. However, the available data are adequate for assessing the impact of those mechanisms by examining the anthropometric differences among occupational groups. Several critical areas of difference are examined in this report. The results of our statistical analyses indicate that, in almost every instance, it is the demographic components (age, race, and sex) that contribute to the anthropometric differences among occupation groups. This leads to the conclusion that the anthropometric characteristics of occupational groups are essentially identical. Thus, any future change that occurs among occupational groups will most likely result from change in the demographic composition of the Army population.

2. MATERIALS AND METHODS

Population

Class distinctions are responsible for many differences among the subgroups of a population. Since occupation groups can be seen as a form of ethnic, or class,

distinction (Barth 1969), it would be useful to this analysis to remove, or control for, all other class distinctions that might exist in the Army population. The Army population is a class hierarchical structure. Although military rank is an obvious class structure, the promotion process detracts from its utility as a class distinction. Rank advancement would be largely indistinguishable from the biological effects of aging. However, the distinction between officer and enlisted personnel constitutes a barrier over which there is very little membership exchange. This distinction can be controlled by focusing on the occupation groups within only one of these classes. Enlisted personnel represent the majority group in the Army and are the backbone of its workforce. Therefore, it is appropriate to limit this investigation to the population of enlisted personnel.

Race

Race constitutes another potential source of differences among population subgroups. Race distinctions are normally thought of as having a biological basis, but in American society race is also an important determinant of social class. Official Army policy does not consider racial differences when making occupational assignments. Still, it would be naive to assume that race is irrelevant. Because the Army strives for racial integration, it would be inappropriate to limit this investigation to any particular racial group. Instead, the influence of race is controlled statistically by including race affiliation as an important factor.

Detailed data on race and ethnic group affiliation are available for almost every soldier. These data could be used to make extremely fine racial/ethnic group distinctions. Meaningful interpretations of these differences require proper identification of group affiliation. However, Gordon and Bell (1991) found inconsistencies in the racial/ethnic classifications of many soldiers, especially among minority groups. Based on these findings, soldiers can be consistently assigned to only three different racial groupings: Whites, Blacks, and Others[1]. The racial group Other represents a miscellaneous population that cannot be associated with biological interpretations on par with the White and Black groups. This distinction, however, has little impact on this study since Whites and Blacks together comprise over 90% of the enlisted Army population (see Table 1).

Table 1. US Army Enlisted Personnel: February 1988 Demographic Breakdown

	Whites	Blacks	Others	Totals
Men	375250 (56.5%)	167287 (25.2%)	49505 (7.5%)	592042 (89.1%)
Women	34843 (5.2%)	32320 (4.9%)	4893 (0.7%)	72056 (10.9%)
Totals	410093 (61.8%)	199607 (30.1%)	54398 (8.2%)	664098 (100%)

[1]The racial group "Others" includes Hispanics, Asian Pacific Islanders and American Indians.

Occupation Groups

Each member of the Army has a specific job, which is known as a Military Occupational Specialty (MOS). Enlisted personnel are distributed among approximately 360 different MOS classifications. Although the MOS is supposed to reflect soldiers' occupational training, soldiers do not always keep the same MOS designation throughout their military careers. The Army combines, eliminates, or creates MOSs as new technologies reshuffle required skills. Further, some MOSs are set aside as leadership positions, so that as soldiers advance in rank they may change their MOS designations. To provide some structure to these designations, the Army groups related enlisted MOSs into a Career Management Field (CMF). Since CMFs represent a higher level grouping, they represent a more stable, and therefore useful, designation of soldiers' occupation groups. There are 33 different CMFs in the Army; four CMFs are currently closed to female soldiers (see Tables 2 and 3).

Table 2. Career Management Field Populations: MEN[2]

CMF Code	CMF	Frequency	Percent
11	Infantry[a]	78861	13.3%
63	Mechanical Maintenance[b]	69035	11.7%
31	Signal Operations	49753	8.4%
13	Field Artillery[b]	47081	8.0%
76	Supply and Service	40440	6.8%
91	Medical	35339	6.0%
71	Administration	31534	5.3%
19	Armor[a]	30408	5.1%
95	Law Enforcement[c]	22718	3.8%
88	Transportation	20622	3.5%
67	Aircraft Maintenance	20578	3.5%
12	Combat Engineering[a]	17675	3.0%
94	Food Service	16117	2.7%
16	Air Defense Artillery[b]	13966	2.4%
29	Communications-Electronics System Maintenance	13347	2.3%
51	General Engineering[a]	11906	2.0%
98	Electronic Warfare/Cryptologic Operations	9094	1.5%
77	Petroleum and Water	9043	1.5%
54	Chemical	8278	1.4%
96	Military Intelligence[b]	6944	1.2%
55	Ammunition	5506	0.9%
27	Land Combat Air Defense Direct and General System Maintenance[b]	4740	0.8%
79	Recruitment and Reenlistment	4039	0.7%
93	Aviation Operations[b]	3318	0.6%
23	Air Defense System Maintenance	3232	0.5%
18	Special Forces	3212	0.5%
74	Record Information Operations	3108	0.5%
35	Electronic Maintenance and Calibration	2850	0.5%
97	Bands	2395	0.4%
33	Electronic Warfare/Intercept Systems Maintenance	1687	0.3%
25	Visual Information	1227	0.2%
81	Topographic Engineering	980	0.2%
46	Public Affairs	709	0.1%
	College Trainees Officer Candidates and Command Sergeant Majors	2187	0.4%
	MISSING DATA	443	
	Enlisted Men Total	592042	

[2]Data for this table were provided by PERSINSCOM and are accurate as of February 1988.

[a] Entire CMF closed to women soldiers.

[b] Some MOS's within CMF closed to female soldiers.

[c] Entire CMF has anthropometric restrictions on membership.

Table 3. Career Management Field Populations: WOMEN[3]

CMF Code	CMF	Frequency	Percent
71	Administration	18726	26.0%
91	Medical	12899	17.9%
76	Supply and Service	8036	11.2%
31	Signal Operations	750	10.4%
94	Food Service	3082	4.3%
63	Mechanical Maintenance[a]	3026	4.2%
88	Transportation	2985	4.1%
95	Law Enforcement[b]	2724	3.8%
98	Electronic Warfare/Cryptologic Operations	2487	3.5%
96	Military Intelligence[a]	1381	1.9%
77	Petroleum and Water	1318	1.8%
29	Communications-Electronics System Maintenance	953	1.3%
74	Record Information Operations	890	1.2%
54	Chemical[a]	736	1.0%
93	Aviation Operations[c]	730	1.0%
55	Ammunition	578	0.8%
67	Aircraft Maintenance	487	0.7%
16	Air Defense Artillery[a, c]	415	0.6%
25	Visual Information	364	0.5%
35	Electronic Maintenance and Calibration	358	0.5%
97	Bands	337	0.5%
27	Land Combat, Air Defense, Direct and General System Maintenance[b]	323	0.4%
81	Topographic Engineering	288	0.4%
51	General Engineering[a, c]	287	0.4%
46	Public Affairs	278	0.4%
13	Field Artillery[b]	273	0.4%
79	Recruitment and Reenlistment	262	0.4%
33	Electronic Warfare/Intercept Systems Maintenance	114	0.2%
23	Air Defense System Maintenance	80	0.1%
	College Trainees, Officer Candidates, and Command Sergeant Majors	64	0.1%
	MISSING DATA	68	
	Enlisted Women Total	72056	

[3]Data for this table were provided by PERSINSCOM and is accurate as of February 1988.

[a] Some MOS's within CMF closed to female soldiers.

[b] Entire CMF has anthropomorphic restrictions on membership.

[c] Some MOS's within CMF have anthropomorphic restrictions on membership.

Data Sets

The data set most appropriate to this investigation stems from the 1988 Anthropometric Survey of U.S. Army Personnel, or ANSUR (Gordon et al., 1989). The ANSUR database contains detailed anthropometric data, covering over 130 body dimensions, for over 8000 soldiers. A subset of 15 body dimensions (see Table 4) was selected to provide the anthropometric focus of this investigation and was chosen to represent overall body size and proportion with a limited number of dimensions (see Appendix A for definitions). Ten CMFs were chosen for analysis, based upon their sample size in ANSUR, and the fact that they also represent the more populous CMFs in the Army. CMFs that have specific anthropometric membership requirements were not included in this sample, with the exceptions of CMF 19 (Armor)[4] and CMF 51 (General Engineering)[5]. These two CMFs were included because of their large populations and their analytical interest. Data on an additional occupation group, CMF 95 (Law Enforcement), were included because of the well known anthropometric restrictions on membership in this group. CMF 95 thus provides a means of showing how known anthropometric requirements affect other important variables associated with occupation groups. CMF 95, however, will not be included during the metric comparison of occupation groups.

Table 4. Body Dimensions Analyzed

Measures of Body Size and Shape	Measures of Body Components
1. STATURE	5. BIACROMIAL BREADTH
2. WEIGHT	6. BUTTOCK CIRCUMFERENCE
3. BODY MASS INDEX	7. CHEST CIRCUMFERENCE
4. ATTENUATION INDEX	8. CROTCH HEIGHT
	9. FOOT LENGTH
	10. HAND CIRCUMFERENCE
	11. HEAD CIRCUMFERENCE
	12. NECK CIRCUMFERENCE
	13. SITTING HEIGHT
	14. SPAN
	15. WAIST CIRCUMFERENCE

This analysis can be viewed as a three-tiered investigation, with each level using an increasingly narrow definition of the research population. The initial research question focuses on the demographic (race/sex) composition of each CMF. This question is best addressed using demographic data that describes the entire Army population. Personnel Information Systems Command (PERSINSCOM) provided a data file that describes the race, sex, and CMF of every enlisted soldier in the Army in the month of February 1988. These data represent a time close to the middle of ANSUR survey. Thus, they are the best representation of the Army's occupational structure during the

[4]CMF 19 has a maximum stature restriction of 73 inches for three of its four MOSs (AR 611-201). Based upon the percentile ranges reported for the Army by Gordon et al., 1989, this restriction excludes less than 10% of the Army population.

[5]Two of the 22 MOSs in CMF 51 have anthropometric membership restrictions (AR 611-210). In both cases, however, these restrictions only exclude small portions of the Army populations from potential membership.

period covered by the anthropometric survey. These data (Table 5) were used to compare demographic profiles among CMFs.

Table 5. Army Enlisted Personnel Demographic Data: CMF Cell Sizes by Race and Gender

MEN

	Whites	Blacks	Others	TOTAL
CMF 11: Infantry	55858	15829	7174	78861
CMF 13: Field Artillery	26792	16130	4159	47081
CMF 19: Armor	21395	6623	2390	30408
CMF 31: Signal Operations	26788	19141	3824	49753
CMF 51: General Engineering	8523	2662	721	11906
CMF 63: Mechanical Maintenance	47794	16036	5204	69034
CMF 71: Administration	15464	12569	3501	31534
CMF 76: Supply and Service	17197	18353	4560	40110
CMF 88: Transportation	12055	7303	1264	20622
CMF 91: Medical	20315	10913	4111	35339
CMF 95: Law Enforcement	18660	3172	886	22718
TOTAL				437366

WOMEN

	Whites	Blacks	Others	TOTAL
CMF 11: Infantry	0	0	0	0
CMF 13: Field Artillery	167	90	16	273
CMF 19: Armor	0	0	0	0
CMF 31: Signal Operations	3621	3419	464	7504
CMF 51: General Engineering	176	93	18	287
CMF 63: Mechanical Maintenance	1766	1072	188	3026
CMF 71: Administration	6973	10336	1417	18736
CMF 76: Supply and Service	2597	4857	582	8036
CMF 88: Transportation	1395	1424	166	2985
CMF 91: Medical	7056	4888	955	12899
CMF 95: Law Enforcement	2078	542	104	2724
TOTAL				56460

The Army's demographic data also establish a template that describes the race and sex membership proportions of each CMF. This template was used in the stratified random sampling of the ANSUR data to create the anthropometric data sets. First, the ANSUR screening data (about 25,000 soldiers) were sampled to create an occupations body size database (Table 6) that mirrors the demographic profile for CMFs within the Army population. This data set contains only information on stature and weight, and thus is appropriate only for a preliminary analysis of general body size and shape differences among the occupation groups. Then a data set containing the suite of body

dimensions described in Table 4 was drawn from the ANSUR data pool. This occupation anthropometric database (Table 7) contains information on all 15 anthropometric dimensions and was used in the comparison of specific body dimensions among CMFs.

Table 6. Occupations Body Size Data: CMF Cell Sizes by Race and Gender

MEN

	Whites	Blacks	Others	TOTAL
CMF 11: Infantry	1570	446	202	2218
CMF 13: Field Artillery	283	170	44	497
CMF 19: Armor	369	114	41	524
CMF 31: Signal Operations	521	373	75	969
CMF 51: General Engineering	218	68	19	305
CMF 63: Mechanical Maintenance	1475	495	160	2130
CMF 71: Administration	312	254	71	637
CMF 76: Supply and Service	615	657	163	1435
CMF 88: Transportation	344	208	36	588
CMF 91: Medical	403	217	81	701
CMF 95: Law Enforcement	218	37	10	265
TOTAL				10269

WOMEN

	Whites	Blacks	Others	TOTAL
CMF 11: Infantry	0	0	0	0
CMF 13: Field Artillery	0	0	0	0
CMF 19: Armor	0	0	0	0
CMF 31: Signal Operations	239	225	31	495
CMF 51: General Engineering	0	0	0	0
CMF 63: Mechanical Maintenance	183	111	19	313
CMF 71: Administration	481	620	85	1123
CMF 76: Supply and Service	238	446	53	737
CMF 88: Transportation	97	99	12	208
CMF 91: Medical	337	233	46	616
CMF 95: Law Enforcement	58	15	3	76
TOTAL				3568

Table 7. Occupations Anthropometric Data Base: CMF Cell Sizes by Race and Gender

MEN

	Whites	Blacks	Others	TOTAL
CMF 11: Infantry	176	50	23	249
CMF 13: Field Artillery	27	16	4	47
CMF 19: Armor	62	19	7	88
CMF 31: Signal Operations	96	69	14	179
CMF 51: General Engineering	32	10	3	45
CMF 63: Mechanical Maintenance	196	66	21	283
CMF 71: Administration	68	55	15	138
CMF 76: Supply and Service	85	91	23	199
CMF 88: Transportation	71	43	7	121
CMF 91: Medical	84	45	17	146
CMF 95: Law Enforcement	43	7	2	52
TOTAL				1547

WOMEN

	Whites	Blacks	Others	TOTAL
CMF 11: Infantry	0	0	0	0
CMF 13: Field Artillery	0	0	0	0
CMF 19: Armor	0	0	0	0
CMF 31: Signal Operations	93	88	12	193
CMF 51: General Engineering	0	0	0	0
CMF 63: Mechanical Maintenance	74	45	8	127
CMF 71: Administration	225	334	46	605
CMF 76: Supply and Service	96	179	221	296
CMF 88: Transportation	38	39	5	82
CMF 91: Medical	182	126	25	333
CMF 95: Law Enforcement	31	8	2	41
TOTAL				1677

3. RESULTS AND DISCUSSION

Are CMFs Demographically Balanced?

The February 1988 demographic data file shows that Army Enlisted personnel span about 360 different military occupational specialties, which are grouped into 33 CMFs for 592,042 men and 29 CMFs for 72,056 women. This analysis focused on 11 CMFs that account for almost 75% of the Army's male and female populations. Table 1 reports the demographic profile of the Army enlisted population as a whole. These proportions (male/female, White/Black/Other) are used to examine the demographic balance among the targeted CMFs.

Race and Gender

This first research question focused on race and sex distributions: do CMF memberships vary in their race/sex proportions? Because female membership is restricted in four CMFs, the obvious answer to this question, at least in terms of sex, was yes. Therefore, the statistical analysis of this question dropped those CMFs (11, 13, 19, and 51) that restrict female membership. The resulting data were examined using log linear analysis (SAS Institute, Inc. 1988) of a Race by Sex by CMF interaction model. This analysis tested the null hypothesis that there were no proportional differences in membership among the race/sex/CMF categories. Table 8 reports the results of this analysis. These results rejected the null hypothesis ($p < .05$), and thus supported a conclusion that race/sex groups are not equally distributed among CMFs.

Table 8. Log Linear Analysis of CMF Demographics[6]

MAXIMUM LIKELIHOOD ANALYSIS OF VARIANCE TABLE

SOURCE	*df*	Chi-Square	*p*
RACE	2	25742.91	<.0001
SEX	1	37303.69	<.0001
RACE*SEX	2	1394.75	<.0001
CMF	6	11590.44	<.0001
RACE*CMF	12	7505.53	<.0001
SEX*CMF	6	9868.74	<.0001
RACE*SEX*CMF	12	259.07	<.0001
LIKELIHOOD RATIO	0	----	----

Although the demographic profiles of the CMFs were significantly different from each other, it is also important to know how each individual CMF might differ from the Army population as a whole. The Army demographic profile indicates that the

[6]Excludes the following CMF's because of their known restrictions on female membership: CMF 11 (Infantry), CMF 13 (Field Artillery), CMF 19 (Armor), and CMF 51 (General Engineering).

enlisted population is 89.1% male and 10.9% female. These proportions were used to calculate expected frequencies for each CMF population, again excluding those CMFs that restrict female membership. For each CMF these expected frequencies were compared with their observed frequencies using chi-square analysis (SAS Institute, Inc. 1988). This method tested the null hypothesis that observed and expected frequencies are equal. Table 9 reports the results of these tests. Except for CMF 95 (Law Enforcement), these tests rejected the null hypotheses ($p < .05$, corrected for 9 comparisons). Thus, men and women were not randomly distributed among CMFs. This conclusion justifies separate examination of males and females in further analyses.

Next, racial distributions were compared between each CMF and the population as a whole. The Army demographic profile indicates race distributions of 63.4% White, 28.3% Black, and 8.4% Other among men and 48.4% White, 44.9% Black, and 6.8% Other among women. As before, these race proportions were used to calculate expected frequencies that were compared to observed frequencies for each CMF using SAS chi-square analysis. Table 10 reports results for men (11 CMFs), and Table 11 reports results for women (excluding CMFs that bar female membership). These results show that race distributions in each CMF were significantly different from the expected population values for men ($p < .05$, corrected for 11 comparisons). For women, only the test of CMF 31 (Signal Operations) failed to reject the null hypothesis. For all other CMFs, female race frequencies were significantly different from their expected values ($p < .05$, corrected for 9 comparisons).

Age

Finally, it is important to know if occupation groups have different age distributions. Many anthropometric dimensions change during the aging process (Bradtmiller et al.,1985; Cline et al., 1989; Randall, 1949). Therefore, if CMFs differ by age, then age may be an important covariate in analyzing anthropometric differences. Although age is a continuous variable, its distribution is strongly skewed toward younger individuals in a military population. Therefore, age distributions among CMFs were analyzed using the Kruskal-Wallis test (Sokal and Rohlf, 1981) instead of the usual ANOVA, which assumes normal distributions. The age distributions of CMFs within each race/sex group were compared using the K-W option within the NPAR procedure of $SPSS_X$. Although the entire demographic data set could be used to analyze the female population, this data set exceeded computer (IBM 4381) memory limitations for the analysis of the male population. Therefore, a randomly selected subset (40% was the largest usable fraction) was used to compare male age distributions. Tables 12 and 13 present the results of these analyses. These results show that age distributions were significantly different among CMFs ($P < .05$, corrected for three comparisons) for all racial groups within both sexes.

The combined results of these analyses show that CMF's did not have equivalent age, race and sex proportions. These results can be used to argue that social mechanisms that distinguish among age, race and sex groups are influential in the determination of CMF membership. It is beyond the scope of this analysis to tease out specific causes and responses to such social mechanisms. However, age, gender and race significantly affect anthropometric distributions, so they are important covariates in later analyses of anthropometric differences among CMF membership. Still, it is important to realize that social change could have a strong influence on the anthropometric relationships among CMFs in the future.

Table 9. Comparison of CMF Gender Distribution

CMF	Observed	Expected	Chi-Square	*df*	*p*
13 Field Artillery			5196.4	1	.000
Males	47081.00	42192.41			
Females	273.00	5161.58			
31 Signal Operations			286.9	1	.000
Males	49753.00	51015.98			
Females	7504.00	6241.01			
51 General Engineering			917.0	1	.000
Males	11906.00	10863.96			
Females	287.00	1329.04			
63 Mechanical Maintenance			3331.6	1	.000
Males	69035.00	64206.35			
Females	3026.00	7854.64			
71 Administration			35954.4	1	.000
Males	31534.00	44781.66			
Females	18726.00	5478.34			
76 Supply and Service			1662.4	1	.000
Males	40110.00	42898.08			
Females	8036.00	5247.91			
88 Transportation			74.0	1	.000
Males	20622.00	21033.84			
Females	2985.00	2573.16			
91 Medical			12462.8	1	.000
Males	35339.00	42980.05			
Females	12899.00	5257.94			
95 Law Enforcement			1.0	1	.323
Males	22718.00	22668.82			(not signif.)
Females	2724.00	2773.18			

Table 10. Comparison of CMF Race Distributions for Enlisted Men

CMF	Observed	Expected	Chi-Squared	*df*	*p*
11 Infantry			2621.5	2	.000
Whites	55858.00	49947.92			
Blacks	15829.00	22295.36			
Others	7174.00	6617.70			
13 Field Artillery			915.5	2	.000
Whites	26792.00	29819.53			
Blacks	16130.00	13310.61			
Others	4159.00	3950.85			
19 Armor			700.3	2	.000
Whites	21395.00	19259.41			
Blacks	6623.00	8596.86			
Others	2390.00	2551.72			
31 Signal Operations			2568.7	2	.000
Whites	26788.00	31511.89			
Blacks	19141.00	14066.03			
Others	3824.00	4175.07			
51 General Engineering			352.6	2	.000
Whites	8523.00	7540.86			
Blacks	2662.00	3366.03			
Others	721.00	999.10			
63 Mechanical Maintenance			1059.7	2	.000
Whites	47794.00	43723.83			
Blacks	16036.00	19517.10			
Others	5204.00	5793.06			
71 Administration			2791.3	2	.000
Whites	15464.00	19972.58			
Blacks	12569.00	8915.20			
Others	3501.00	2646.21			
76 Supply and Service			7412.6	2	.000
Whites	17197.00	25404.33			
Blacks	18353.00	11339.79			
Others	4560.00	3365.87			
88 Transportation			575.3	2	.000
Whites	12055.00	13061.29			
Blacks	7303.00	5830.19			
Others	1264.00	1730.52			
91 Medical			718.6	2	.000
Whites	20315.00	22382.54			
Blacks	10913.00	9990.94			
Others	4111.00	2965.51			
95 Law Enforcement			3459.3	2	.000
Whites	18660.00	14388.82			
Blacks	3172.00	6422.77			
Others	886.00	1906.41			

Table 11. Comparison of CMF Race Distributions for Enlisted Women

CMF	Observed	Expected	Chi-Squared	*df*	*p*
13 Field Artillery			18.2	2	.000
Whites	167.00	132.00			
Blacks	90.00	122.45			
Others	16.00	18.55			
31 Signal Operations			5.0	2	.084
Whites	3621.00	3628.31			(not signif.)
Blacks	3419.00	3365.93			
Others	464.00	509.76			
51 General Engineering			20.0	2	.000
Whites	176.00	138.77			
Blacks	93.00	128.73			
Others	18.00	19.50			
63 Mechanical Maintenance			124.2	2	.000
Whites	1766.00	1463.12			
Blacks	1072.00	1357.32			
Others	188.00	205.56			
71 Administration			941.4	2	.000
Whites	6973.00	9054.33			
Blacks	10336.00	8399.57			
Others	1417.00	1272.09			
76 Supply and Service			864.9	2	.000
Whites	2597.00	3885.54			
Blacks	4857.00	3604.56			
Others	582.00	545.90			
88 Transportation			13.7	2	.001
Whites	1395.00	1443.30			
Blacks	1424.00	1338.93			
Others	166.00	202.78			
91 Medical			254.0	2	.000
Whites	7056.00	6236.88			
Blacks	4888.00	5785.86			
Others	955.00	876.25			
95 Law Enforcement			853.3	2	.000
Whites	2078.00	1317.10			
Blacks	542.00	1221.85			
Others	104.00	185.05			

Table 12. Kruskal-Wallis Test of CMF Age Differences for Enlisted Men*

White Men

Mean Rank	Cases	CMF	
44272.94	22355	11	Chi-Square: 3447.4
48604.52	10550	13	
51181.37	8453	19	Corrected for Tied Ranks
48148.57	10727	31	Chi-Square: 3467.2
52176.73	3438	51	
49659.53	19069	63	$p < .0001$
66997.88	6201	71	
52637.64	6892	76	
52531.60	4792	88	
55244.66	8128	91	
Total Cases:	100605		

Black Men

Mean Rank	Cases	CMF	
26202.24	6302	11	Chi-Square: 1062.0
20675.23	6519	13	
24265.79	2702	19	Corrected for Tied Ranks
24608.40	7522	31	Chi-Square: 1065.4
25161.90	1070	51	
24388.29	6296	63	$p < .0001$
28751.76	5013	71	
25117.15	7251	76	
25489.99	2958	88	
26779.49	4362	91	
Total Cases:	49995		

Other Men

Mean Rank	Cases	CMF	
6700.98	2863	11	Chi-Square: 589.2
6167.64	1637	13	
6915.90	958	19	Corrected for Tied Ranks
7144.75	1548	31	Chi-Square: 590.9
7692.50	270	51	
7081.01	2069	63	$p < .0001$
9385.04	1357	71	
7846.29	1802	76	
7824.39	533	88	
7884.53	1634	91	
Total Cases:	14671		

*This analysis is based on a randomly selected subset of Army enlisted men, which amounts to approximately 40% of the total population.

Table 13. Kruskal-Wallis Test of CMF Age Differences for Enlisted Women

White Women

Mean Rank	Cases	CMF	
10716.93	3621	31	Chi-Square: 160.5
11933.04	1765	63	
12109.59	6972	71	Corrected for Tied Ranks
10977.06	2596	76	Chi-Square: 161.4
11317.94	1394	88	
12076.91	7055	91	$p < .0001$
Total Cases:	23403		

Black Women

Mean Rank	Cases	CMF	
12645.57	3418	31	Chi-Square: 117.7
11651.24	1072	63	
12892.27	10335	71	Corrected for Tied Ranks
12919.14	4857	76	Chi-Square: 118.2
12699.36	1424	88	
13900.96	4888	91	$p < .0001$
Total Cases:	25994		

Other Women

Mean Rank	Cases	CMF	
1623.24	464	31	Chi-Square: 60.6
1632.83	187	63	
1962.28	1413	71	Corrected for Tied Ranks
1826.12	579	76	Chi-Square: 60.8
1720.36	166	88	
2001.46	955	91	$p < .0001$
Total Cases:	3764		

Do CMFs Differ in Body Size and Shape?

Questions concerning general body size and shape are generally formulated through considerations of Stature and Weight. The first four anthropometric dimensions proposed for this analysis (see Table 4) include measures of soldiers' Stature and Weight and two indices that express the relationship between them. The Body Mass Index (BMI) is a commonly used measure of general body size, expressed in units of kilograms per meter squared. The BMI is used as a quantitative representation of body proportionality. Typically, robust persons will have higher BMIs while the BMIs of lighter framed persons will be lower. The average BMI for Army men, calculated using the Army's anthropometric working database (Gordon et al., 1989), is 25.4 with a standard deviation of 3.0, while the average for Army women is 23.3 with a standard deviation of 2.6. The Attenuation Index is also calculated using Stature and Weight, but it is more a statement of body shape. The Attenuation Index is expressed in units of millimeters per cubed root of Weight in grams (a not entirely successful attempt to make the Attenuation Index a dimensionless unit through the relationship of the millimeter and the gram). The Attenuation Index is used as an anthropometric assessment of body shape that is compatible with somatotyping procedures. The Attenuation Index centers on the value 40; long and thin body shapes have attenuation values greater than 40 while short and thick body shapes are associated with values less than 40. The average Attenuation Index for Army men, again based on the Army's anthropometric working database, is 41.2 with a standard deviation of 1.7, while the average for Army women is 41.4 with a standard deviation of 1.7. Although both the BMI and the Attenuation Index represent combinations of Stature and Weight, their different calculations emphasize distinct relationships and by that relay different sorts of information. BMI is more commonly seen in current research and therefore is probably more familiar to most readers. The main benefit of using the Attenuation Index in this study is that it was also used in a previous study of military occupational group differences (Hooton, 1948; 1959). Therefore, Attenuation Index values provide a direct means of comparison with those results.

The occupational body size database constructed for this study contains information on soldiers' age, sex, race, stature and weight. Tables 14 and 15 provide male and female summary statistics for these dimensions. The analysis of differences among CMFs in these dimensions was addressed through a comparison of means using analysis of variance (ANOVA) (Sokal and Rohlf, 1981). These ANOVA tests were conducted using SAS Proc GLM because it accommodates unequal sample sizes in subgroups (SAS Institute, 1988). Since body size and shape vary among racial groups (Brues, 1977; Molnar, 1983), it was most appropriate to conduct this analysis using a two-factor model of CMF and Race. Change in anthropometric dimensions due to aging could also complicate these relationships (Chumlea et al., 1988; Greiner and Gordon, 1990; 1992). Since age distributions were shown to be significantly different among CMFs (see Tables 12 and 13), ANOVA tests included age as an important covariate.[7] Finally, Stature was included as a potential anthropometric covariate in the analysis of Weight.

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[7]Although age does influence anthropometric dimensions, age distributions were not matched when constructing the demographically balanced data sets, because they caused too great a reduction in available sample size. Instead, age is included as an important statistical covariate but no biologically relevant interpretations should be drawn from its significance levels in these tests.

Table 14. Male Occupations Body Size Data Set Descriptive Statistics by CMF

CMF 11: Infantry

	Combined (n=2218)		Whites (n=1570)		Blacks (n=446)		Others (n=202)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Stature (mm)	1756.50	66.30	1761.90	64.50	1756.10	66.60	1714.80	64.40
Weight (kg)	77.07	10.30	77.00	10.00	78.03	10.70	75.47	11.20
Attenuation	41.40	1.60	41.53	1.60	41.23	1.70	40.74	1.80
Body Mass	24.95	2.80	24.76	2.70	25.28	3.00	25.63	3.20

CMF 13: Field Artillery

	Combined (n=497)		Whites (n=283)		Blacks (n=170)		Others (n=44)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Stature (mm)	1756.00	67.30	1761.50	61.30	1756.10	73.60	1720.80	69.30
Weight (kg)	76.54	10.00	76.28	9.70	77.21	10.30	75.62	10.50
Attenuation	41.65	1.60	41.53	1.60	41.23	1.70	40.74	1.80
Body Mass	24.81	2.90	24.56	2.60	25.05	3.10	25.56	3.40

CMF 19: Armor

	Combined (n=524)		Whites (n=369)		Blacks (n=114)		Others (n=41)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Stature (mm)	1753.90	65.40	1759.30	64.00	1751.60	63.20	1711.40	68.50
Weight (kg)	77.94	10.70	77.87	10.40	78.95	11.50	75.87	10.80
Attenuation	41.20	1.80	41.33	1.70	40.99	1.80	40.57	1.80
Body Mass	25.32	3.10	25.14	3.00	25.69	3.20	25.89	3.20

CMF 31: Signal Operations

	Combined (n=969)		Whites (n=521)		Blacks (n=373)		Others (n=75)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Stature (mm)	1756.40	66.00	1760.00	63.70	1757.20	68.80	1727.50	61.40
Weight (kg)	77.82	10.60	77.49	10.40	78.52	10.90	76.62	10.30
Attenuation	41.27	1.80	41.41	1.80	41.17	1.80	40.80	1.70
Body Mass	25.21	3.00	25.01	3.00	25.41	3.10	25.65	3.00

CMF 51: General Engineering

	Combined (n=305)		Whites (n=218)		Blacks (n=68)		Others (n=19)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Stature (mm)	1749.40	66.70	1751.20	68.40	1752.30	59.30	1718.50	66.90
Weight (kg)	77.72	11.00	77.81	11.20	78.57	10.60	73.68	9.50
Attenuation	41.13	1.60	41.16	1.60	41.04	1.60	41.10	1.70
Body Mass	25.34	2.90	25.31	2.80	25.56	3.00	24.94	2.90

CMF 63: Mechanical Maintenance

	Combined (n=2130)		Whites (n=1475)		Blacks (n=495)		Others (n=160)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Stature (mm)	1754.80	67.20	1757.50	64.20	1758.80	70.40	1717.50	72.80
Weight (kg)	77.52	11.10	77.27	10.90	78.78	11.60	75.91	11.10
Attenuation	41.30	1.70	41.41	1.70	41.18	1.70	40.70	1.80
Body Mass	25.14	3.00	24.98	3.00	25.42	3.10	25.70	3.10

CMF 71: Administration

	Combined (n=637)		Whites (n=312)		Blacks (n=254)		Others (n=71)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Stature (mm)	1751.80	71.30	1760.20	71.10	1754.20	69.80	1706.00	61.30
Weight (kg)	77.50	11.20	78.41	11.30	77.68	11.10	72.92	10.10
Attenuation	41.23	1.70	41.26	1.60	41.26	1.90	40.97	1.60
Body Mass	25.22	3.00	25.26	2.90	25.23	3.20	25.01	2.90

Table 14. Male Occupations Body Size Data Set Descriptive Statistics by CMF (Continued)

CMF 76: Supply and Service

	Combined (n=1435)		Whites (n=615)		Blacks (n=657)		Others (n=163)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Stature (mm)	1749.30	66.50	1753.80	66.00	1754.80	64.40	1709.90	64.40
Weight (kg)	77.06	11.00	77.09	10.90	77.79	11.10	74.01	10.00
Attenuation	41.25	1.80	41.35	1.70	41.26	1.80	40.85	1.60
Body Mass	25.15	3.10	25.03	3.00	25.23	3.20	25.29	2.90

CMF 88: Transportation

	Combined (n=588)		Whites (n=344)		Blacks (n=208)		Others (n=36)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Stature (mm)	1752.00	65.60	1750.90	62.30	1756.00	68.60	1738.08	78.30
Weight (kg)	77.99	11.10	77.32	10.80	79.10	11.20	78.04	12.60
Attenuation	41.15	1.80	41.24	1.70	41.05	1.80	40.87	2.00
Body Mass	25.38	3.10	25.19	3.10	25.63	3.10	25.78	3.50

CMF 91: Medical

	Combined (n=701)		Whites (n=403)		Blacks (n=217)		Others (n=81)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Stature (mm)	1755.10	69.00	1761.30	66.50	1758.10	67.30	1716.00	73.90
Weight (kg)	77.92	11.10	77.23	10.40	80.47	12.10	74.52	10.20
Attenuation	41.23	1.70	41.49	1.60	40.88	1.80	40.90	1.80
Body Mass	25.26	3.00	24.86	2.80	25.99	3.30	25.31	3.00

Table 15. Female Occupations Body Size Data Set Descriptive Statistics by CMF

CMF 31: Signal Operations

	Combined (n=495)		Whites (n=239)		Blacks (n=225)		Others (n=31)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Stature (mm)	1626.70	62.70	1627.80	63.90	1628.50	61.10	1606.50	63.60
Weight (kg)	61.61	7.80	61.11	7.80	62.36	7.80	60.11	7.00
Attenuation	41.29	1.60	41.44	1.70	41.17	1.50	41.09	1.40
Body Mass	23.27	2.10	23.05	2.50	23.49	2.50	23.27	2.10

CMF 63: Mechanical Maintenance

	Combined (n=313)		Whites (n=183)		Blacks (n=111)		Others (n=19)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Stature (mm)	1634.90	61.30	1637.30	55.80	1637.10	66.30	1598.10	72.70
Weight (kg)	63.00	8.40	63.00	8.30	63.06	8.60	62.70	8.30
Attenuation	41.21	1.60	41.28	1.70	41.25	1.60	40.30	1.20
Body Mass	23.55	2.60	53.48	2.70	23.49	2.50	24.50	2.10

CMF 71: Administration

	Combined (n=1123)		Whites (n=481)		Blacks (n=620)		Others (n=85)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Stature (mm)	1626.60	62.60	1624.70	65.90	1632.20	59.80	1594.10	56.10
Weight (kg)	61.56	8.40	60.34	8.30	62.71	8.30	59.25	9.10
Attenuation	41.32	1.70	41.55	1.60	41.21	1.70	41.05	1.60
Body Mass	23.24	2.70	22.82	2.60	23.52	2.70	23.25	2.80

CMF 76: Supply and Service

	Combined (n=737)		Whites (n=238)		Blacks (n=446)		Others (n=53)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Stature (mm)	1626.80	62.70	1631.10	63.90	1628.90	60.10	1589.70	68.40
Weight (kg)	62.36	8.10	61.44	7.30	63.03	8.40	60.90	8.80
Attenuation	41.14	1.60	41.43	1.60	41.05	1.60	40.54	1.60
Body Mass	23.54	2.60	23.09	2.40	23.73	2.60	24.04	2.60

CMF 88: Transportation

	Combined (n=208)		Whites (n=97)		Blacks (n=99)		Others (n=12)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Stature (mm)	1633.60	56.20	1635.80	51.70	1629.10	60.10	1652.80	57.00
Weight (kg)	63.00	8.30	64.11	8.30	61.68	8.20	65.01	9.10
Attenuation	41.18	1.60	40.99	1.60	41.36	1.70	41.22	1.20
Body Mass	23.54	2.60	23.93	2.60	23.23	2.70	23.71	2.20

CMF 91: Medical

	Combined (n=616)		Whites (n=337)		Blacks (n=233)		Others (n=46)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Stature (mm)	1628.40	64.70	1630.60	60.70	1629.00	68.40	1609.50	71.30
Weight (kg)	62.14	8.00	61.96	7.90	62.65	8.00	60.88	8.90
Attenuation	41.23	1.70	41.32	1.70	41.12	1.70	41.06	1.90
Body Mass	23.42	2.60	23.29	2.60	23.60	2.60	23.48	2.90

The ANOVA results in Table 16 present three levels of information. First, located at the top of the ANOVA tables for each dimension is an assessment of the significance of the statistical model. Next, these tables report two means of analyzing the components of the ANOVA model. The first of these analyses is the result of a Type I ANOVA, which examines each factor in a hierarchical fashion (SAS Institute, 1988). Type I results report the significance of each factor as a building block toward the entire model. Thus, using the example of the ANOVA for Stature, the significance of Age is assessed first. This is followed by a test of the significance of Race when controlling for the effects of Age. Next, the contribution of CMF differences are evaluated, while controlling for the effects of Age and Race. Finally, the interaction effect of CMF by Race is evaluated, while controlling for the independent effects of the other factors. The second analysis of the model components is the result of a Type III ANOVA. Type III results report the significance of individual factors while controlling for all of the other effects (SAS Institute, 1988). Thus, again using the example of Stature, the significance of Age within the model is assessed while controlling for the effects of Race, CMF, and CMF by Race. Next, the significance of Race is assessed, while controlling for the effects of Age, CMF, and CMF by Race. This pattern continues for each factor, so that the assessment of the final factor (CMF by Race) produces the same result in the Type I and Type III analyses. The research goal is to determine if body size and shape differ among CMFs, while controlling for all other potentially influencing factors. Thus, the hierarchical model building of Type I does not fully match this goal. The approach of Type III analyses, however, does match the research goal. Therefore, Type I results are provided for completeness, but interpretations are based upon the Type III results.

Examinations of the ANOVA results for males showed that all models were significant ($p < .05$, when controlling for four comparisons). Yet, differences among CMFs were not significant when controlling for the other factors. Similarly, none of the CMF by Race interaction terms was significant; only Race stood out as a significant factor in these models. These results suggested that, for males, body size and shape differences among CMFs were best attributed to differences in their racial compositions.

The ANOVA results for females did not match the male results. As for males, tests of female Stature and Attenuation Index found that Race was the only significant factor ($p < .05$, when controlling for four comparisons). However, the results for Weight and BMI showed that Race was not a significant factor, but that CMF was significant. Again, CMF by Race interaction terms were not significant in any of these tests. These results suggested that differences in Stature and body shape linearity (as measured by the Attenuation Index) were best attributed to the differences among the races. Still, occupational groups did contribute to observable differences in Weight and body proportionality (as measured by the BMI). These latter results called for a post-hoc analysis of CMF differences to identify the CMFs that were responsible for these results. Due to the unbalanced subgroup size in this sample, the Tukey-Kramer test (employed through the Tukey option of Proc GLM in SAS) was the most appropriate post-hoc test (Sokal and Rohlf, 1981; SAS Institute, 1988). Table 17 presents a graphic representation of the results of this test for Weight; no two CMFs were significantly different in the post-hoc test of BMI. CMF 63 (Mechanical Maintenance) and CMF 71 (Administration) were identified as the unique groups in this sample. These two CMFs represented the occupation groups with, respectively, the highest and lowest observed mean values for Weight. These two occupation groups also represented the CMFs with the largest and second smallest sample sizes in the data set. Finally, the maximum observed difference among CMF means for Weight is only 1.4 kg

(3.1 lb). Therefore, these differences probably have very little biological or equipment engineering relevance.

Table 16. Comparative ANOVAs for Male and Female Body Size Variables

MALE STATURE					
Source	*df*	Sum of Squares	Mean Square	*F*	*p* > *F*
Model	30	1582603.186	52753.4400	12.14	0.0001
Error	9971	43320421.0170	4344.6420		
Corrected Total	10001	44903024.204			
Source	*df*	Type I *SS*	Mean Square	*F*	*p* > *F*
AGE	1	82895.9	82895.9020	19.08	0.0001
RACE	2	1378211.291	689105.6460	158.61	0.0001
CMF	9	50693.0	5632.5590	1.30	0.2328
CMF*RACE	18	70802.9	3933.4980	0.91	0.5719
Source	*df*	Type III *SS*	Mean Square	*F*	*p* > *F*
AGE	1	30072.7	30072.7011	6.92	0.0085
RACE	2	742466.96	371233.4835	85.45	0.0001
CMF	9	43224.9	4802.7730	1.11	0.3547
CMF*RACE	18	70802.9	3933.4977	0.91	0.5719
FEMALE STATURE					
Source	*df*	Sum of Squares	Mean Square	*F*	*p* > *F*
Model	18	300825.07	16712.5040	4.34	0.0001
Error	3473	13362092.7389	3847.4209		
Corrected Total	3491	13662917.8107			
Source	*df*	Type I *SS*	Mean Square	*F*	*p* > *F*
AGE	1	15487.5	15487.5571	4.03	0.0449
RACE	2	199508.65	99754.3281	25.93	0.0001
CMF	5	24560.3	4912.0708	1.28	0.2709
CMF*RACE	10	61268.5	6126.8505	1.59	0.1023
Source	*df*	Type III *SS*	Mean Square	*F*	*p* > *F*
AGE	1	19104.02	19104.02133	4.97	0.0259
RACE	2	77924.27	38962.13770	10.13	0.0001
CMF	5	47177.08	9435.41654	2.45	0.0316
CMF*RACE	10	61268.50	6126.85046	1.59	0.1023

Table 16. Comparative ANOVAs for Male and Female Body Size Variables (Continued)

MALE WEIGHT

Source	*df*	Sum of Squares	Mean Square	*F*	$p > F$
Model	31	362183.47	11683.3379	145.16	0.0000
Error	9970	802422.39	80.4837		
Corrected Total	10001	1164605.867			

Source	*df*	Type I *SS*	Mean Square	*F*	$p > F$
AGE	1	36476.8	36476.8143	453.22	0.0001
STATURE	1	321321.98	321321.9836	3992.39	0.0000
RACE	2	1173.	586.8675	7.29	0.0007
CMF	9	1381.	153.5321	1.91	0.0463
CMF*RACE	18	1829.	101.6197	1.26	0.2016

Source	*df*	Type III *SS*	Mean Square	*F*	$p > F$
AGE	1	42438.9	42438.9622	527.30	0.0001
STATURE	1	314115.27	314115.2726	3902.84	0.0000
RACE	2	984	492.1924	6.12	0.0022
CMF	9	1351.	150.2059	1.87	0.0521
CMF*RACE	18	1829.	101.6197	1.26	0.2016

FEMALE WEIGHT

Source	*df*	Sum of Squares	Mean Square	*F*	$p > F$
Model	19	80062.37	4213.80928	94.42	0.0001
Error	3472	154945.504	44.62716		
Corrected Total	3491	235007.881			

Source	*df*	Type I *SS*	Mean Square	*F*	$p > F$
AGE	1	13337.49	13337.49057	298.86	0.0001
STATURE	1	64421.34	64421.34804	1443.55	0.0001
RACE	2	521.	260.54988	5.84	0.0029
CMF	5	820.	164.14586	3.68	0.0025
CMF*RACE	10	961.	96.17087	2.15	0.0178

Source	*df*	Type III *SS*	Mean Square	*F*	$p > F$
AGE	1	11291.90	11291.90234	253.03	0.0001
STATURE	1	62586.36	62586.36150	1402.43	0.0001
RACE	2	139.	69.50726	1.56	0.2108
CMF	5	767.	153.47838	3.44	0.0042
CMF*RACE	10	961.	96.17087	2.15	0.0178

Table 16. Comparative ANOVAs for Male and Female Body Size Variables (Continued)

MALE BODY MASS INDEX

Source	*df*	Sum of Squares	Mean Square	*F*	*p* > *F*
Model	30	5370.11	179.003746	21.29	0.0001
Error	9971	83827.740	8.407155		
Corrected Total	10001	89197.853			

Source	*df*	Type I *SS*	Mean Square	*F*	*p* > *F*
AGE	1	4885.96	4885.961469	581.17	0.0001
RACE	2	145.6	72.835726	8.66	0.0002
CMF	9	147.3	16.368592	1.95	0.0413
CMF*RACE	18	191.1	10.620118	1.26	0.2012

Source	*df*	Type III *SS*	Mean Square	*F*	*p* > *F*
AGE	1	4460.96	4460.966450	530.62	0.0001
RACE	2	118.5	59.267740	7.05	0.0009
CMF	9	147.3	16.373489	1.95	0.0412
CMF*RACE	18	191.1	10.620118	1.26	0.2012

FEMALE BODY MASS INDEX

Source	*df*	Sum of Squares	Mean Square	*F*	*p* > *F*
Model	18	1885.15	104.730560	16.59	0.0001
Error	3473	21923.033	6.312420		
Corrected Total	3491	23808.183			

Source	*df*	Type I *SS*	Mean Square	*F*	*p* > *F*
AGE	1	1561.86	1561.863922	247.43	0.0001
RACE	2	78.	39.018206	6.18	0.0021
CMF	5	111.8	22.364762	3.54	0.0034
CMF*RACE	10	133.4	13.342593	2.11	0.0204

Source	*df*	Type III *SS*	Mean Square	*F*	*p* > *F*
AGE	1	1540.02	1540.021605	243.97	0.0001
RACE	2	23.	11.736930	1.86	0.1559
CMF	5	107.1	21.437599	3.40	0.0046
CMF*RACE	10	133.4	13.342593	2.11	0.0204

Table 16. Comparative ANOVAs for Male and Female Body Size Variables (Continued)

MALE ATTENUATION INDEX

Source	*df*	Sum of Squares	Mean Square	*F*	*p* > *F*
Model	30	1827.88	60.929532	21.86	0.0001
Error	9971	27787.436	2.786825		
Corrected Total	10001	29615.322			

Source	*df*	Type I *SS*	Mean Square	*F*	*p* > *F*
AGE	1	1535.74	1535.743994	551.07	0.0001
RACE	2	190.4	95.205352	34.16	0.0001
CMF	9	49.	5.530477	1.98	0.0369
CMF*RACE	18	51.	2.886499	1.04	0.4142

Source	*df*	Type III *SS*	Mean Square	*F*	*p* > *F*
AGE	1	1346.21	1346.213705	483.06	0.0001
RACE	2	109.0	54.512560	19.56	0.0001
CMF	9	33.	3.735546	1.34	0.2099
CMF*RACE	18	51.	2.886499	1.04	0.4142

FEMALE ATTENUATION INDEX

Source	*df*	Sum of Squares	Mean Square	*F*	*p* > *F*
Model	18	562.74	31.2633339	12.26	0.0001
Error	3473	8854.449	2.5495102		
Corrected Total	3491	9417.189			

Source	*df*	Type I *SS*	Mean Square	*F*	*p* > *F*
AGE	1	435.17	435.1774097	170.69	0.0001
RACE	2	53.3	26.6511710	10.45	0.0001
CMF	5	32.2	6.4537664	2.53	0.0270
CMF*RACE	10	41.9	4.1991426	1.65	0.0874

Source	*df*	Type III *SS*	Mean Square	*F*	*p* > *F*
AGE	1	425.24	425.2481578	166.80	0.0001
RACE	2	27.2	13.6196191	5.34	0.0048
CMF	5	34.0	6.8022041	2.67	0.0206
CMF*RACE	10	41.9	4.1991426	1.65	0.0874

Table 17. Tukey-Kramer Post-Hoc Comparison of Weight in Kg among Female CMFs[1]

Mean		CMF 31	CMF 63	CMF 71	CMF 76	CMF 88	CMF 91
61.6	CMF 31		*				
63.0	CMF 63	*		*			
61.6	CMF 71		*			*	
62.4	CMF 76						
63.0	CMF 88			*			
62.1	CMF 91						

At this point in the analysis it becomes relevant to ask if CMF body sizes and shapes differ from the values observed for the Army as a whole. This question was addressed by using the $SPSS_X$ *t*-test procedure to compare sample means for each CMF with values derived from the Army's anthropometric working database (Gordon et al., 1989). Tables 18 and 19 present the results of these comparisons for male and female CMFs. No female CMFs were shown to be significantly different from the Army female population. Among the comparison of male CMFs, four occupation groups stand out. With regards to the measurements of Stature and Weight, CMF 76 (Service and Supply) was significantly smaller than the overall Army male population, but did not show the same differences in the proportionality of body size and shape as measured by the BMI and the Attenuation Index. CMF 63 (Mechanical Maintenance) was shown to be significantly smaller in Weight, but in no other measure of body size and shape. Finally, CMFs 11 (Infantry) and 13 (Field Artillery) were shown to be significantly different from the Army male population in every measure of body size and shape except Stature. Their Weights and BMI measurements were smaller than the mean Army values, while they had larger figures for Attenuation Indexes.

[1]Paired comparisons significantly different at the .05 level are indicated by an asterisk(*).

Table 18. Comparison of Male CMF Body Size and Shape Dimensions with the Entire Population of Army Men

STATURE (Army Mean 1756 mm)				
CMF	Mean	*t*	*n*	*p*
11	1756	1.09	2218	0.276
13	1756	0.81	497	0.419
19	1754	1.47	524	0.141
31	1756	0.89	969	0.371
51	1749	2.25	305	0.024
63	1755	1.83	2130	0.068
71	1752	1.12	637	0.027
76	1749	3.99	1435	0.000*
88	1752	2.14	588	0.033
91	1755	1.22	701	0.244
WEIGHT (Army Mean 78.5 kg)				
CMF	Mean	*t*	*n*	*p*
11	77.1	4.82#	2218	0.000*
13	76.5	4.22#	497	0.000*
19	77.9	1.48	524	0.139
31	77.8	2.13	969	0.034
51	77.7	1.52	305	0.130
63	77.5	3.41	2130	0.001*
71	77.5	2.42	637	0.015
76	77.1	4.27	1435	0.000*
88	78.0	1.44	588	0.149
91	77.9	1.68	701	0.093
BODY MASS INDEX (Army Mean 25.4)				
CMF	Mean	*t*	*n*	*p*
11	25.0	4.81	2218	0.000*
13	24.8	3.94	497	0.000*
19	25.3	0.57	524	0.570
31	25.2	1.59	969	0.112
51	25.3	0.32	305	0.746
63	25.1	2.71	2130	0.007
71	25.2	1.36	637	0.174
76	25.2	2.31	1435	0.021
88	25.4	0.14	588	0.890
91	25.3	1.04	701	0.299
ATTENUATION INDEX (Army Mean 41.2)				
CMF	Mean	*t*	*n*	*p*
11	41.4	-4.04	2218	0.000*
13	41.5	-3.47	497	0.000*
19	41.2	-0.18	524	0.857
31	41.3	-1.36	969	0.175
51	41.1	0.52	305	0.605
63	41.3	-2.15	2130	0.031
71	41.2	-0.62	637	0.537
76	41.3	-1.13	1435	0.258
88	41.2	0.36	588	0.721
91	41.2	1.73	701	0.507

* Difference between CMF and Army population means are significant ($p < .05$, adjusted for 10 comparisons).

Reported value of *t* is an estimate based upon unequal sample variances.

Table 19. Comparison of Female CMF Body Size and Shape Dimensions with the Entire Population of Army Women

STATURE (Army Mean 1629 mm)				
CMF	Mean	*t*	*n*	*p*
31	1627	1.28	495	0.202
63	1635	-1.07	313	0.284
71	1627	1.81	1123	0.070
76	1627	1.46	737	0.143
88	1634	-0.62	208	0.538
91	1628	0.81	616	0.418
WEIGHT (Army Mean 62.0 kg)				
CMF	Mean	*t*	*n*	*p*
31	61.6	0.99#	495	0.320
63	63.0	-1.81	313	0.071
71	61.6	1.39#	1123	0.164
76	62.4	-0.95#	737	0.340
88	63.0	-1.50	208	0.134
91	62.1	-0.32#	616	0.747
BODY MASS INDEX (Army Mean 23.3)				
CMF	Mean	*t*	*n*	*p*
31	23.3	0.20#	495	0.841
63	23.5	-1.44	313	0.151
71	23.2	0.50#	1123	0.619
76	23.5	-2.16#	737	0.031
88	23.6	-1.37	208	0.170
91	23.4	-1.03#	616	0.301
ATTENUATION INDEX (Army Mean 41.4)				
CMF	Mean	*t*	*n*	*p*
31	41.3	0.16	495	0.877
63	41.2	0.99	313	0.322
71	41.3	-0.29	1123	0.773
76	41.1	2.40	737	0.017
88	41.2	1.08	208	0.282
91	41.2	1.01	616	0.310

* Difference between CMF and Army population means are significant ($p < .05$, adjusted for 6 comparisons).

Reported value of *t* is an estimate based upon unequal sample variances.

None of these statistically significant differences is very large. Figure 1 displays the relationships among male and female CMFs as measured by their mean values of Stature and Weight. This figure illustrates the separations among CMFs, and that the differences were small. For both men and women, CMFs differed by less than 1 cm and by less than 1.5 kg. It is also interesting to note that two occupation groups with some anthropometric restrictions (CMFs 19 and 51), did not stand out in any way. Thus, the results of these analyses suggest that differences in body size and shape among these occupation groups probably need not be considered during the design or allocation of clothing and individual equipment.

Have CMF Body Shapes Changed Over Time?

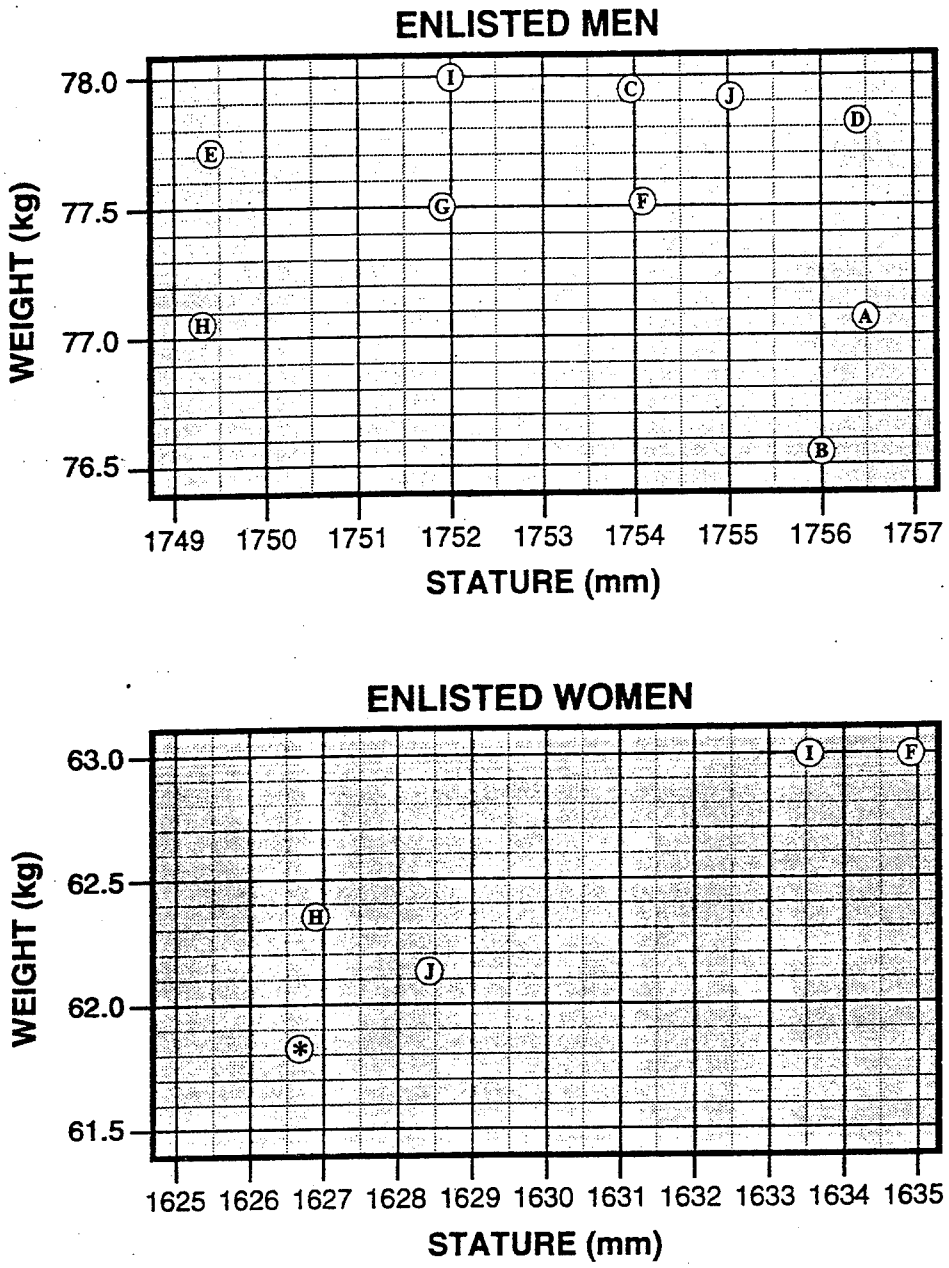
As part of the 1946 anthropometric survey of US. Army personnel, Earnest Hooton and colleagues undertook an analysis of the variations and associations of body builds within the Army population (Hooton, 1948; 1959; Bullen, 1948). One aim of these studies was to make "special group analyses to indicate whether or not there are distinct constitutional types of men and women who engage in particular military activities" (Hooton, 1948:1). Inasmuch as Hooton's aims and methods matched those of the present study, those results provide a means to find out if military occupations show stable patterns of body size and shape over time.

Hooton's data consist of front, back, and side nude photographs, and measurements of Stature and Weight (converted into the Attenuation Index) for 31,568 White men. Somatotyping is the primary data reduction method. Each individual is graded on three seven point scales: muscular development, fat development, and attenuation. Values for the Attenuation Index are converted into the seven point scale by dividing the range between the observed minimum and maximum values into seven equal steps. Thus, each individual is graded by a three digit combination. These combinations are, in turn, grouped into 18 categories, which range from "thin, nonmuscular, elongate" to "very fat, very muscular" (Hooton, 1948:iii).

Hooton does not outline the criteria used to identify military occupation groups, so direct comparisons of results are difficult. Still, eight occupation groups are named that seem to be close equivalents to the CMFs used in the present study. Correspondingly, Bullen (1948) limits her study of Army women to subdivisions of the Women's Army Corps and the Army Nurse Corps personnel. These two categories of Army women might be seen as equivalents to CMFs 71 (Administration) and 91 (Medical). Their subdivisions, however, permitted no clear comparison between the occupation groups of women in the 1946 and 1988 Armies.

Hooton describes no real differences among occupational groups based upon their average values, but concentrates on differences in their distributions. Thus, Hooton's interpretations seem to rely less on statistical analysis than on a visual inspection of the ranges of distributional variation. Hooton concludes that:

> The fattest men are in the supply corps, the least muscular and apparently weakest in administration. But, of course, all specialties consist of most of the body build types and selection rarely operates so as to exclude all of the presumably unfitted body types from a particular group. [Hooton, 1948:xi]



KEY

SYMBOL	CMF #	OCCUPATION
A	CMF 11	INFANTRY
B	CMF 13	FIELD ARTILLERY
C	CMF 19	ARMOR
D	CMF 31	SIGNAL OPERATIONS
E	CMF 51	GENERAL ENGINEERING
F	CMF 63	MECHANICAL MAINTENANCE
G	CMF 71	ADMINISTRATION
H	CMF 76	SUPPLY and SERVICE
I	CMF 88	TRANSPORTATION
J	CMF 91	MEDICAL
*	CMFs 31 &71	(Values Overlap)

Figure 1. Plots of the relationship between Stature and Weight among the CMFs by Sex.

By this statement, Hooton implies that the supply corps distribution is visibly skewed toward the "fat" end of the fatness somatotype component. Similarly, men in the administration occupational group are visibly skewed toward the "non-muscular" end of the muscularity somatotype component. Although Hooton notes that every body type can be found within every occupational group, he considers certain body types to be more suited to specific occupational tasks. He further concludes that:

> The present survey of body types on a sample of the Army indicates marked tendencies for men of different body builds to gravitate into particular military units and military specialties. This result must come about as a combination of "natural selection," policies of assignment, and free choice of the individuals concerned. [Hooton, 1948:xvi]

Hooton's reported attenuation values were the only data that could be compared with the current study. Figure 2 graphically presents the distribution of attenuation grades within occupation groups for White enlisted men in 1946 and 1988. To match Hooton's methods, the Attenuation Index was converted into a seven point scale by dividing its range into seven equal steps.

Visual inspection of Attenuation grade distributions for White men in the 1946 and 1988 Armies suggests several rough patterns of change. First, it appeared that for all occupation groups, extreme body types (1's and 7's) were less common in 1988 then they were in 1946. This pattern was most evident in the comparisons of the medical and administration occupation groups. Within this trend, gunnery/infantry showed a general shift to the higher attenuation grades (long-thin) at the expense of the lower grades (short-thick). All the other occupational groups showed a shift to more peaked distributions, focusing on the central Attenuation grade. These redistributions represented a somewhat greater decline in the frequency of the short-thick body type. Given that the Attenuation Index is more sensitive to Stature than to Weight differences, these interpretations were not inconsistent with conclusions concerning secular trends within the Army population (Greiner and Gordon, 1990).

In sum, a visual comparison of Attenuation distributions suggests that occupation groups have become more similar. If this interpretation is correct, it suggests that the forces of selection, natural or otherwise, responsible for the differences among occupation groups acted very differently in 1946 than they do in 1988.

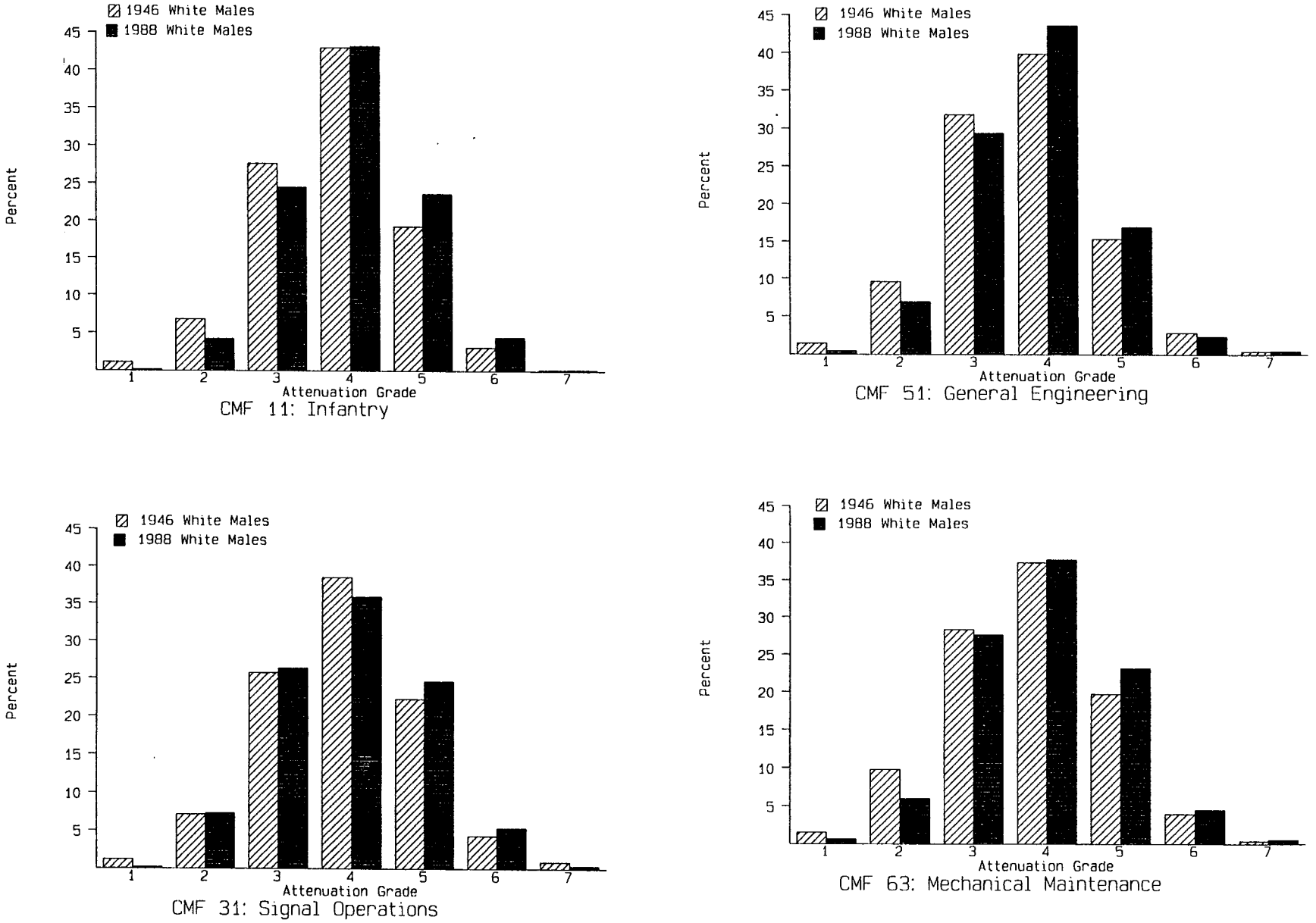


Figure 2. Distribution of Attenuation grades within occupation groups for White enlisted men in 1946; Hooton (1948) and 1988.

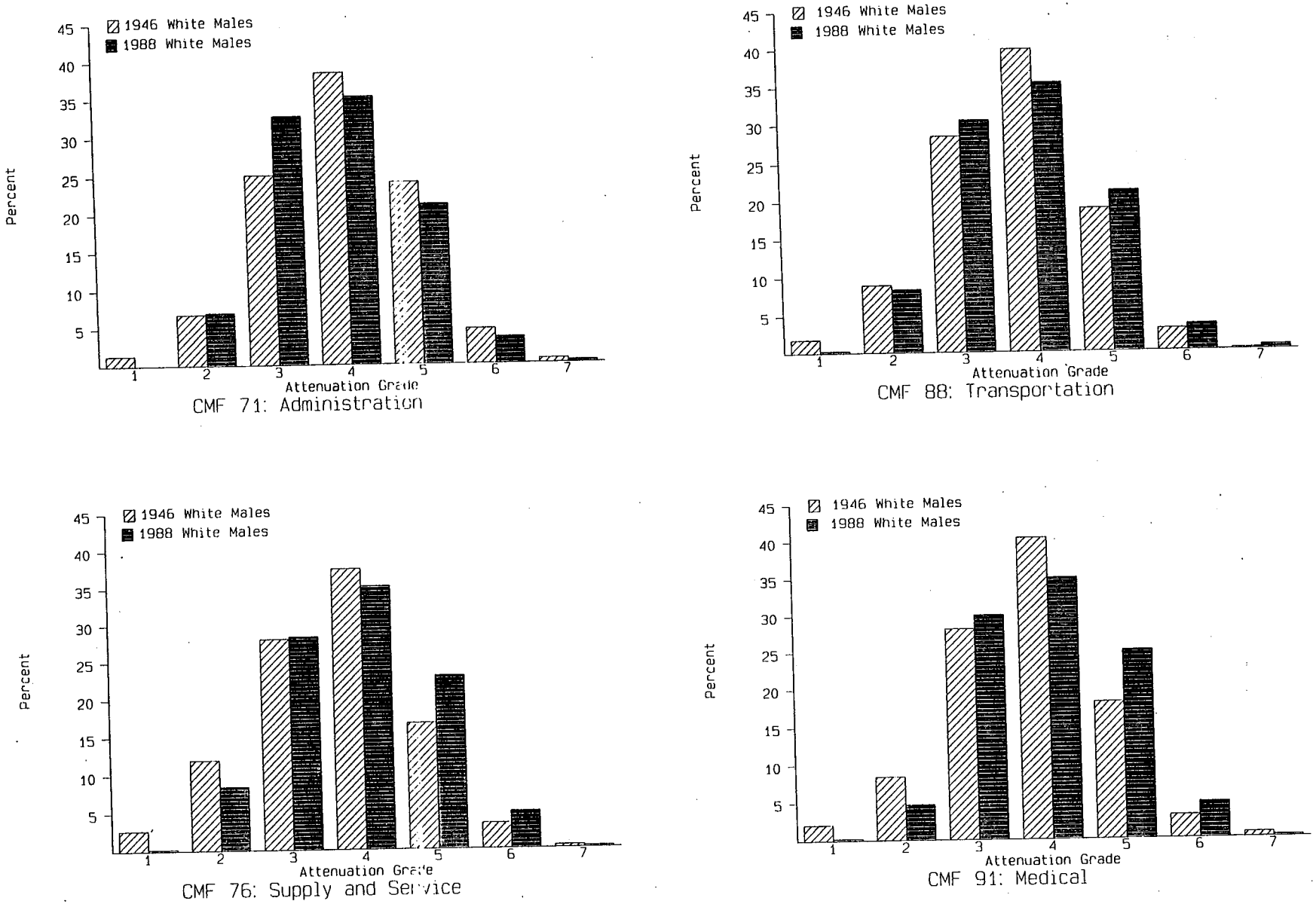


Figure 2. Distribution of Attenuation grades within occupation groups for White enlisted men in 1946; Hooton (1948) and 1988 (continued).

Do CMFs Differ in Specific Anthropometric Dimensions?

Questions concerning differences among specific anthropometric dimensions (as opposed to overall body size) of CMF membership were addressed through essentially the same methods used in the analyses of body size and shape. The last 11 dimensions proposed for this analysis (see Table 4: Body Dimensions Analyzed) comprise a representative cross section of the body dimensions collected during the 1988 Anthropometric Survey (Gordon et al., 1989). These data were collated into an Occupations Anthropometric Data Base to reflect the Army's demographic profile of each CMF chosen for this analysis. Tables 20 and 21 present the descriptive summary statistics for these male and female data sets. The analysis of differences among CMFs in these anthropometric dimensions were addressed through an analysis of variance (ANOVA), using the same models and methods outlined above. Table 22 shows the comparative results of these ANOVA tests.

For reasons identical with those previously outlined, the results presented in Table 22 are interpreted by focusing on the Type III results. These results show that the evaluated models are significant ($p < .05$, when controlling for 11 comparisons) for each examined dimension for both males and females. Four dimensions for males (Biacromial Breadth, Buttock Circumference, Head Circumference, and Neck Circumference) and two dimensions for females (Buttock Circumference and Neck Circumference) are shown to have no significant differences among CMFs when controlling for Age, Stature, and Race. For these dimensions, model significance is due to the effects of either Stature or Age. The bulk of the other anthropometric dimensions for both males and females also show no significant differences among CMFs, but include Race as a significant factor. In no case is the interaction of CMF and Race shown to be significant. However, one dimension for each sex (Hand Circumference for males; Chest Circumference for females) is significantly different by CMF, despite the presence of Age, Stature, and Race as controlling factors. These two dimensions are examined using the Tukey-Kramer post-hoc evaluation. Tables 23 and 24 graphically present the results of these tests. In both instances, CMFs 71 (Administration) and 88 (Transportation) stand out as the occupation groups with the most unique values. These groups also represent the highest and lowest mean values for either dimension. Yet, in Hand Circumference for men, the difference between minimum and maximum group means amounts to only 2 mm, which hardly seems relevant for clothing and equipment design. For Chest Circumference among women, the same range amounts to 30 mm. Although this is a larger difference, it is a similarly small fraction of a Chest Circumference measurement. Therefore, this difference is also probably not relevant for clothing and equipment design.

With the addition of Stature and Weight, 13 anthropometric dimensions described the membership of each CMF. These dimensions are used to assess the relationships among CMFs as a multivariate problem. Canonical discriminant analysis was chosen as the statistical method for this task (Reyment et al., 1984). Canonical discriminant analysis acts by weighting each variable to maximize the separation among successive group pairs in multivariate space, and thus emphasizes the differences among groups. These actions result in a series of canonical variates, totaling one less than the number of available groups, that underscore group distinctions. Interpretations are based upon the significance of the canonical variates, the proportion of intergroup variation accounted for by the variates, and the distance separating group centroids in multivariate space.

Table 20. Male Occupations Anthropometric Database Descriptive Statistics in mm by CMF

CMF 11: Infantry

	Combined		Whites		Blacks		Others	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Biacromial Brth	399.0	17.3	398.6	17.3	403.2	17.2	393.0	15.4
Buttock Circ	986.6	61.0	990.5	59.5	984.4	66.7	961.8	55.3
Chest Circ	999.3	70.0	1006.1	72.4	983.9	58.8	981.4	68.1
Crotch Height	836.4	42.4	832.6	38.5	861.9	46.7	809.7	35.8
Foot Length	269.9	11.9	268.9	11.1	275.3	12.4	265.6	13.8
Hand Circ	213.4	9.1	213.2	8.6	215.9	10.4	209.7	8.8
Head Circ	565.3	14.9	566.1	14.7	563.6	15.6	562.6	14.6
Neck Circ	379.0	18.7	379.1	18.9	381.9	18.7	372.7	16.7
Sitting Height	914.8	36.3	924.6	30.4	889.2	37.4	896.3	41.7
Span	1825.8	74.4	1816.1	66.9	1875.3	79.8	1793.0	72.1
Waist Circ	859.0	83.5	869.1	84.2	832.8	79.2	838.1	73.1

CMF 13: Field Artillery

	Combined		Whites		Blacks		Others	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Biacromial Brth	391.0	22.3	390.7	25.1	393.6	17.8	382.8	21.3
Buttock Circ	976.7	63.0	976.7	63.0	972.0	49.5	952.0	55.3
Chest Circ	970.7	65.2	977.1	77.2	964.7	42.3	952.0	59.9
Crotch Height	837.2	41.6	834.4	37.3	852.3	44.0	795.3	34.2
Foot Length	270.1	15.8	269.1	16.6	274.8	14.0	258.5	11.6
Hand Circ	213.2	10.6	215.2	12.0	211.6	6.5	206.3	12.9
Head Circ	568.1	18.2	570.8	19.8	564.4	16.3	565.3	14.7
Neck Circ	376.7	16.6	377.7	18.7	376.0	11.9	372.0	21.1
Sitting Height	909.8	33.1	919.5	32.8	897.2	28.9	895.3	35.9
Span	1819.3	90.3	1814.1	90.2	1846.3	87.1	1745.8	72.2
Waist Circ	833.1	76.4	859.3	77.6	790.8	60.7	825.5	54.6

CMF 19: Armor

	Combined		Whites		Blacks		Others	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Biacromial Brth	400.2	17.4	400.8	17.5	398.6	19.6	398.7	10.6
Buttock Circ	986.9	64.0	989.9	59.3	962.1	54.9	1028.1	102.9
Chest Circ	989.7	67.2	992.5	65.0	968.3	70.2	1022.7	71.0
Crotch Height	846.6	44.9	843.9	45.8	853.7	44.7	851.4	41.0
Foot Length	270.6	12.6	269.1	13.0	273.8	12.9	275.3	4.5
Hand Circ	213.3	8.4	213.2	8.6	213.3	8.3	214.6	7.8
Head Circ	567.6	14.1	567.8	13.2	565.7	15.6	572.0	18.0
Neck Circ	381.6	17.6	382.7	17.2	377.8	17.2	382.9	23.0
Sitting Height	919.7	39.0	932.3	33.4	880.6	31.9	914.3	33.5
Span	1830.4	74.0	1825.5	76.8	1847.6	75.7	1827.6	34.3
Waist Circ	865.4	87.7	877.7	85.2	811.0	70.0	904.0	101.8

CMF 31: Signal Operations

	Combined		Whites		Blacks		Others	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Biacromial Brth	394.3	18.6	393.1	16.6	398.2	20.6	385.7	18.7
Buttock Circ	979.1	58.1	973.5	55.1	986.6	64.6	980.3	41.1
Chest Circ	983.3	62.7	982.5	64.8	984.6	63.2	981.6	47.3
Crotch Height	837.1	49.5	830.5	46.6	852.9	51.2	804.3	33.1
Foot Length	269.7	13.5	265.6	11.9	275.9	13.4	267.3	13.8
Hand Circ	213.3	9.8	212.0	8.3	215.9	11.0	209.8	10.7
Head Circ	567.3	15.0	565.6	14.1	569.2	16.6	569.5	12.5
Neck Circ	378.8	21.2	377.1	19.7	381.9	23.9	375.3	14.8
Sitting Height	906.4	35.3	919.5	29.4	890.3	37.1	896.6	28.4
Span	1816.0	86.7	1792.5	73.0	1857.5	92.0	1772.2	65.7
Waist Circ	844.7	79.3	849.1	79.7	834.2	81.0	866.1	64.6

Table 20. Male Occupations Anthropometric Database Descriptive Statistics in mm by CMF (Continued)

CMF 51: General Engineering

	Combined		Whites		Blacks		Others	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Biacromial Brth	398.5	15.5	399.3	16.2	392.2	13.0	410.7	6.0
Buttock Circ	983.3	60.5	979.3	60.8	976.1	57.7	1050.3	31.8
Chest Circ	979.1	67.8	973.9	66.2	967.0	60.6	1074.3	43.0
Crotch Height	828.4	44.9	829.9	50.0	827.0	33.9	816.3	12.7
Foot Length	268.6	10.7	267.1	11.7	271.8	8.0	273.3	4.2
Hand Circ	214.6	9.6	213.1	8.7	216.1	10.9	225.3	10.7
Head Circ	565.3	11.8	563.9	11.7	567.2	12.2	573.0	9.5
Neck Circ	381.1	19.0	379.9	19.9	377.9	12.0	404.3	18.1
Sitting Height	914.6	34.3	921.5	32.2	886.9	30.3	932.7	24.1
Span	1814.9	65.8	1812.8	66.5	1810.7	73.3	1851.3	19.5
Waist Circ	856.1	80.6	859.0	77.7	813.1	66.9	968.3	32.6

CMF 63: Mechanical Maintenance

	Combined		Whites		Blacks		Others	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Biacromial Brth	396.7	18.3	396.9	18.1	398.1	19.2	391.0	16.9
Buttock Circ	983.1	62.5	984.9	58.0	976.4	68.7	986.6	82.1
Chest Circ	984.8	68.9	991.5	67.8	962.8	60.2	992.3	90.5
Crotch Height	836.4	44.0	831.5	39.4	858.9	46.4	812.0	50.8
Foot Length	270.5	13.2	268.7	12.5	277.4	12.3	266.0	16.0
Hand Circ	214.8	9.5	214.9	9.0	214.6	9.2	214.0	14.7
Head Circ	567.6	15.4	567.3	14.2	569.7	15.9	563.8	22.7
Neck Circ	379.0	19.4	379.4	18.6	377.9	19.1	379.2	27.9
Sitting Height	914.5	33.6	922.2	31.5	894.2	30.7	907.1	35.0
Span	1825.6	83.3	1811.9	77.8	1877.1	73.6	1791.1	96.3
Waist Circ	858.7	87.8	869.7	82.0	820.3	85.4	877.0	114.3

CMF 71: Administration

	Combined		Whites		Blacks		Others	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Biacromial Brth	393.0	16.9	391.7	17.1	393.6	16.1	396.5	19.5
Buttock Circ	972.4	54.4	973.0	50.6	968.5	57.3	984.3	61.8
Chest Circ	974.3	64.4	983.3	63.7	958.7	64.8	990.4	58.0
Crotch Height	836.6	50.3	826.6	47.0	859.2	48.1	798.6	34.5
Foot Length	269.4	12.9	267.3	12.9	273.5	12.9	263.5	8.8
Hand Circ	211.9	9.5	212.4	9.6	213.0	9.4	206.1	7.8
Head Circ	565.2	14.6	564.8	15.8	566.5	13.5	561.8	12.8
Neck Circ	375.6	18.5	374.3	15.5	377.7	21.0	373.2	21.6
Sitting Height	902.4	35.1	920.4	33.5	885.2	28.3	883.9	21.2
Span	1818.7	82.0	1799.9	73.3	1853.8	84.9	1769.2	56.2
Waist Circ	843.6	83.4	859.1	81.9	816.1	76.6	873.9	90.7

CMF 76: Supply and Service

	Combined		Whites		Blacks		Others	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Biacromial Brth	393.0	18.4	396.0	18.8	390.9	17.9	390.6	17.8
Buttock Circ	971.4	60.9	984.1	61.2	964.1	63.4	953.5	38.1
Chest Circ	974.3	65.3	991.7	69.5	961.4	62.2	961.4	46.0
Crotch Height	833.4	46.1	830.2	43.8	845.2	44.0	798.4	44.0
Foot Length	269.2	12.6	267.8	11.6	272.2	12.9	262.7	12.5
Hand Circ	212.5	10.2	213.1	10.0	212.5	10.1	210.7	11.5
Head Circ	565.0	14.7	567.0	14.0	564.8	14.7	558.3	16.0
Neck Circ	377.1	19.8	380.5	18.8	375.1	21.0	372.7	17.0
Sitting Height	900.7	37.7	924.4	30.7	880.4	31.5	893.7	35.0
Span	1817.7	81.7	1814.4	69.9	1835.1	86.3	1760.9	78.9
Waist Circ	843.2	88.2	878.6	86.4	812.1	84.4	835.5	58.1

Table 20. Male Occupations Anthropometric Database Descriptive Statistics in mm by CMF (Continued)

CMF 88: Transportation

	Combined		Whites		Blacks		Others	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Biacromial Brth	397.5	18.8	395.9	20.1	399.2	17.0	403.1	15.0
Buttock Circ	980.7	60.6	974.1	63.7	986.6	50.9	1011.6	78.0
Chest Circ	985.9	68.7	978.9	73.3	990.7	51.5	1026.6	101.9
Crotch Height	844.0	50.3	830.8	46.0	869.2	46.9	823.9	58.4
Foot Length	272.0	14.0	268.2	14.3	278.0	11.3	273.7	13.1
Hand Circ	215.9	9.3	214.1	8.5	218.2	9.8	219.4	11.0
Head Circ	567.6	15.2	564.2	14.0	573.4	13.9	566.0	23.9
Neck Circ	378.7	20.9	374.8	21.0	383.0	15.7	392.7	36.4
Sitting Height	914.8	37.9	926.7	34.0	894.9	38.1	917.0	22.5
Span	1831.5	86.5	1804.2	79.9	1879.5	76.5	1813.3	90.7
Waist Circ	852.1	85.6	853.5	91.1	840.0	66.4	912.0	116.9

CMF 91: Medical

	Combined		Whites		Blacks		Others	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Biacromial Brth	396.5	16.8	394.3	18.0	399.3	15.2	400.1	13.6
Buttock Circ	980.8	62.9	975.0	58.9	987.9	71.5	990.7	58.1
Chest Circ	987.6	62.6	987.5	67.1	984.3	58.2	996.5	52.5
Crotch Height	837.0	49.6	830.7	46.1	856.7	49.2	816.2	53.6
Foot Length	269.9	14.2	266.5	13.2	276.8	13.5	268.8	14.7
Hand Circ	213.5	9.9	212.6	9.5	215.2	10.3	213.1	10.2
Head Circ	567.7	17.9	567.7	17.6	568.2	18.3	566.4	19.8
Neck Circ	378.2	18.9	377.3	18.4	380.7	20.7	376.0	16.6
Sitting Height	909.2	37.5	921.0	34.8	889.9	35.5	901.8	33.6
Span	1824.8	87.5	1804.6	83.6	1866.1	79.6	1815.5	93.5
Waist Circ	858.2	82.6	858.4	83.0	851.8	84.4	874.5	78.2

Table 21. Female Occupations Anthropometric Database Descriptive Statistics in mm by CMF

CMF 31: Signal Operations

	Combined		Whites		Blacks		Others	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Biacromial Brth	360.8	16.7	357.0	17.1	364.5	15.4	362.9	16.8
Buttock Circ	957.9	59.0	961.1	58.1	954.6	58.4	957.6	72.9
Chest Circ	905.6	59.9	909.4	59.0	898.4	56.8	929.4	83.5
Crotch Height	772.2	45.5	764.5	44.3	784.6	44.2	739.7	37.8
Foot Length	243.7	12.3	241.0	11.3	247.3	12.2	239.0	12.9
Hand Circ	185.6	8.6	184.3	7.4	187.3	9.1	183.6	11.4
Head Circ	544.3	14.3	541.8	13.8	547.5	14.3	540.8	14.9
Neck Circ	316.0	14.4	314.0	12.6	318.5	15.7	312.7	16.5
Sitting Height	848.0	36.7	866.2	34.7	828.8	27.8	847.4	39.0
Span	1668.1	79.9	1645.1	77.8	1697.2	73.1	1633.3	76.8
Waist Circ	787.5	80.2	786.6	73.7	783.2	83.1	826.8	102.6

CMF 63: Mechanical Maintenance

	Combined		Whites		Blacks		Others	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Biacromial Brth	361.8	17.6	362.2	17.7	361.4	18.0	360.9	15.1
Buttock Circ	955.4	56.1	957.6	60.4	954.1	50.9	943.1	46.0
Chest Circ	908.2	64.7	916.6	67.9	892.5	59.3	919.0	51.8
Crotch Height	773.4	42.6	764.9	38.6	793.6	36.8	737.6	61.7
Foot Length	243.6	12.1	240.4	11.4	249.7	10.4	238.4	14.7
Hand Circ	187.1	9.6	186.1	9.5	188.4	10.1	188.9	12.4
Head Circ	544.7	13.9	541.6	13.6	550.8	12.7	540.0	13.8
Neck Circ	316.9	14.8	317.3	15.9	316.6	14.0	314.9	7.6
Sitting Height	854.8	34.9	868.4	31.6	833.9	28.5	846.3	39.6
Span	1672.0	78.9	1656.7	72.6	1702.7	69.4	1640.6	130.7
Waist Circ	785.0	78.4	792.0	83.9	773.0	72.3	788.3	52.9

CMF 71: Administration

	Combined		Whites		Blacks		Others	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Biacromial Brth	361.1	18.0	357.4	18.7	364.3	17.2	356.5	15.6
Buttock Circ	959.0	61.5	959.0	59.5	965.4	62.0	937.5	63.0
Chest Circ	899.0	63.2	901.2	68.3	898.9	59.5	888.7	64.1
Crotch Height	771.6	45.3	757.1	41.3	786.5	42.8	733.8	36.5
Foot Length	245.0	12.3	239.6	11.7	249.5	10.9	238.5	11.8
Hand Circ	185.7	8.5	183.7	8.3	187.6	8.0	181.2	9.2
Head Circ	546.6	14.9	542.2	14.2	550.2	14.8	542.2	12.7
Neck Circ	314.6	15.5	312.6	16.7	316.8	14.3	308.2	15.3
Sitting Height	843.3	33.3	859.7	32.9	832.9	29.1	838.5	32.4
Span	1675.6	82.6	1638.6	76.4	1707.6	73.6	1624.4	73.2
Waist Circ	786.4	83.6	791.3	86.3	783.1	82.4	786.2	79.7

Table 21. Female Occupations Anthropometric Database Descriptive Statistics in mm by CMF (Continued)

CMF 76: Supply and Service

	Combined		Whites		Blacks		Others	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Biacromial Brth	362.9	16.8	362.0	14.5	363.7	18.0	360.8	16.9
Buttock Circ	965.5	58.7	970.7	57.6	965.3	60.8	943.0	39.2
Chest Circ	907.0	60.1	912.4	58.6	903.8	61.4	909.7	56.0
Crotch Height	775.4	45.7	757.1	42.5	789.8	41.3	736.4	45.0
Foot Length	245.8	11.7	241.1	9.8	249.5	10.8	236.5	14.4
Hand Circ	187.5	8.7	186.3	7.7	188.8	8.9	182.1	9.5
Head Circ	546.1	15.4	541.3	14.7	548.9	15.5	544.6	11.5
Neck Circ	317.4	15.0	319.0	15.4	317.6	14.2	308.9	17.3
Sitting Height	844.7	35.6	865.9	32.7	835.6	32.2	824.6	31.3
Span	1682.4	78.8	1645.1	66.4	1709.0	74.4	1626.3	70.9
Waist Circ	787.6	78.4	800.6	82.2	779.7	77.0	795.6	67.0

CMF 88: Transportation

	Combined		Whites		Blacks		Others	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Biacromial Brth	361.8	17.8	359.9	19.4	363.9	16.5	359.6	17.3
Buttock Circ	979.0	60.8	989.2	58.7	966.9	63.9	995.6	39.7
Chest Circ	928.6	70.4	934.3	66.4	915.8	69.3	985.4	89.5
Crotch Height	777.2	42.2	763.6	32.4	791.9	45.2	765.0	54.3
Foot Length	245.5	12.6	239.2	10.3	252.4	11.2	239.2	12.2
Hand Circ	187.8	8.6	185.5	9.1	190.5	7.6	184.2	6.9
Head Circ	547.0	16.2	542.2	16.3	552.6	14.0	539.8	19.7
Neck Circ	318.7	14.4	319.3	15.6	318.1	13.7	320.0	13.0
Sitting Height	855.6	29.4	863.7	28.1	847.5	30.0	856.8	18.5
Span	1682.0	82.9	1645.3	60.5	1722.9	82.3	1642.6	100.2
Waist Circ	808.7	88.0	815.5	79.7	792.7	93.5	882.0	74.7

CMF 91: Medical

	Combined		Whites		Blacks		Others	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Biacromial Brth	361.6	17.7	358.9	17.7	364.8	17.8	364.5	14.5
Buttock Circ	968.2	62.1	968.2	59.5	971.0	62.5	954.0	78.2
Chest Circ	909.8	64.7	908.8	63.1	910.1	66.6	914.6	68.0
Crotch Height	767.4	43.9	756.3	36.7	786.8	44.0	750.4	56.9
Foot Length	243.5	11.9	240.2	10.3	248.9	11.8	240.2	13.2
Hand Circ	185.6	8.1	183.9	7.5	188.4	8.3	183.2	8.2
Head Circ	546.6	15.6	543.5	13.5	551.9	17.3	542.2	14.5
Neck Circ	316.6	15.1	314.6	14.1	320.1	16.2	313.0	13.8
Sitting Height	850.7	34.9	861.8	31.8	837.0	32.4	838.9	41.0
Span	1665.0	81.0	1636.4	65.8	1707.8	80.6	1658.0	91.3
Waist Circ	796.5	82.2	802.0	81.6	788.1	79.9	798.0	97.5

Table 22. Comparative ANOVAs for Male and Female Occupations Anthropometric Database Variables

MALE BIACROMIAL BREADTH					
Source	*df*	Sum of Squares	Mean Square	*F*	$p > F$
Model	31	135216.0613	4361.8084	18.06	0.0001
Error	1463	353281.9828	241.4778		
Corrected Total	1494	488498.0441			
Source	*df*	Type I *SS*	Mean Square	*F*	$p > F$
AGE	1	366.7945	366.7945	1.52	0.2180
STATURE	1	123386.1282	123386.1282	510.96	0.0001
RACE	2	1441.6437	720.8219	2.99	0.0508
CMF	9	5960.6867	662.2985	2.74	0.0035
CMF*RACE	18	4060.8082	225.6005	0.93	0.5361
Source	*df*	Type III *SS*	Mean Square	*F*	$p > F$
AGE	1	190.0203	190.0203	0.79	0.3752
STATURE	1	116683.8476	116683.8476	483.21	0.0001
RACE	2	1730.3276	865.1638	3.58	0.0280
CMF	9	3698.4572	410.9397	1.70	0.0837
CMF*RACE	18	4060.8082	225.6005	0.93	0.5361
FEMALE BIACROMIAL BREADTH					
Source	*df*	Sum of Squares	Mean Square	*F*	$p > F$
Model	19	130540.1758	6870.5356	29.87	0.0001
Error	1616	371701.4355	230.0133		
Corrected Total	1635	502241.6112			
Source	*df*	Type I *SS*	Mean Square	*F*	$p > F$
AGE	1	1422.8583	1422.8583	6.19	0.0130
STATURE	1	114187.6502	114187.6502	496.44	0.0001
RACE	2	10850.3694	5425.1847	23.59	0.0001
CMF	5	447.0282	89.4056	0.39	0.8568
CMF*RACE	10	3632.2697	363.2270	1.58	0.1069
Source	*df*	Type III *SS*	Mean Square	*F*	$p > F$
AGE	1	184.9591	184.9591	0.80	0.3700
STATURE	1	115131.0693	115131.0693	500.54	0.0001
RACE	2	5206.1789	2603.0894	11.32	0.0001
CMF	5	1246.3783	249.2757	1.08	0.3674
CMF*RACE	10	3632.2697	363.2270	1.58	0.1069

Table 22. Comparative ANOVAs for Male and Female Anthropometric Database Values (Continued)

MALE BUTTOCK CIRCUMFERENCE					
Source	*df*	Sum of Squares	Mean Square	*F*	$p > F$
Model	31	1060145.1700	34198.2310	11.30	0.0001
Error	1463	4429254.5660	3027.5150		
Corrected Total	1494	5489399.7360			
Source	*df*	Type I *SS*	Mean Square	*F*	$p > F$
AGE	1	209653.9159	209653.9159	69.25	0.0001
STATURE	1	751884.6881	751884.6881	248.35	0.0001
RACE	2	12566.6506	6283.3253	2.08	0.1259
CMF	9	25883.8298	2875.9811	0.95	0.4803
CMF*RACE	18	60156.0859	3342.0048	1.10	0.3417
Source	*df*	Type III *SS*	Mean Square	*F*	$p > F$
AGE	1	202005.2450	202005.2450	66.72	0.0001
STATURE	1	694579.0467	694579.0467	229.42	0.0001
RACE	2	25605.1368	12802.5684	4.23	0.0147
CMF	9	28094.2149	3121.5794	1.03	0.4125
CMF*RACE	18	60156.0859	3342.0048	1.10	0.3417
FEMALE BUTTOCK CIRCUMFERENCE					
Source	*df*	Sum of Squares	Mean Square	*F*	$p > F$
Model	19	1222530.417	64343.706	21.79	0.0001
Error	1616	4770796.211	2952.225		
Corrected Total	1635	5993326.628			
Source	*df*	Type I *SS*	Mean Square	*F*	$p > F$
AGE	1	484042.4955	484042.4955	163.96	0.0001
STATURE	1	686516.6812	686516.6812	232.54	0.0001
RACE	2	2896.2616	1448.1308	0.49	0.6124
CMF	5	23287.0119	4657.4024	1.58	0.1632
CMF*RACE	10	25787.9666	2578.7967	0.87	0.5576
Source	*df*	Type III *SS*	Mean Square	*F*	$p > F$
AGE	1	401842.0383	401842.0383	136.11	0.0001
STATURE	1	647573.8848	647573.8848	219.35	0.0001
RACE	2	9082.6440	4541.3220	1.54	0.2151
CMF	5	12518.1808	2503.6362	0.85	0.5156
CMF*RACE	10	25787.9666	2578.7967	0.87	0.5576

Table 22. Comparative ANOVAs for Male and Female Anthropometric Database Values (Continued)

MALE CHEST CIRCUMFERENCE					
Source	*df*	Sum of Squares	Mean Square	*F*	$p > F$
Model	31	1291672.5570	41666.8570	11.28	0.0001
Error	1463	5403198.9110	3693.2320		
Corrected Total	1494	6694871.4690			
Source	*df*	Type I *SS*	Mean Square	*F*	$p > F$
AGE	1	440847.9408	440847.9408	119.37	0.0001
STATURE	1	607158.5237	607158.5237	164.40	0.0001
RACE	2	99426.6341	49713.3171	13.46	0.0001
CMF	9	58889.1012	6543.2335	1.77	0.0691
CMF*RACE	18	85350.3576	4741.6865	1.28	0.1885
Source	*df*	Type III *SS*	Mean Square	*F*	$p > F$
AGE	1	438288.8446	438288.8446	118.67	0.0001
STATURE	1	539097.8373	539097.8373	145.97	0.0001
RACE	2	67134.5539	33567.2770	9.09	0.0001
CMF	9	41562.3403	4618.0378	1.25	0.2598
CMF*RACE	18	85350.3576	4741.6865	1.28	0.1885
FEMALE CHEST CIRCUMFERENCE					
Source	*df*	Sum of Squares	Mean Square	*F*	$p > F$
Model	19	789815.6851	41569.2466	11.64	0.0001
Error	1616	5773273.1240	3572.5700		
Corrected Total	1635	6563088.8090			
Source	*df*	Type I *SS*	Mean Square	*F*	$p > F$
AGE	1	389634.4754	389634.4754	109.06	0.0001
STATURE	1	273808.9334	273808.9334	76.64	0.0001
RACE	2	44889.0463	22444.5232	6.28	0.0019
CMF	5	50243.8672	10048.7734	2.81	0.0155
CMF*RACE	10	31239.3628	3123.9363	0.87	0.5567
Source	*df*	Type III *SS*	Mean Square	*F*	$p > F$
AGE	1	347263.0803	347263.0803	97.20	0.0001
STATURE	1	264687.3941	264687.3941	74.09	0.0001
RACE	2	65198.7484	32599.3742	9.12	0.0001
CMF	5	61803.7703	12360.7541	3.46	0.0041
CMF*RACE	10	31239.3628	3123.9363	0.87	0.5567

Table 22. Comparative ANOVAs for Male and Female Anthropometric Database Values (Continued)

MALE CROTCH HEIGHT					
Source	*df*	Sum of Squares	Mean Square	*F*	$p > F$
Model	31	2530533.081	81630.099	173.76	0.000
Error	1463	687278.391	469.773		
Corrected Total	1494	3217811.472			
Source	*df*	Type I *SS*	Mean Square	*F*	$p > F$
AGE	1	26155.763	26155.763	55.68	0.0001
STATURE	1	2223153.947	2223153.947	4732.40	0.0000
RACE	2	267183.525	133591.763	284.37	0.0001
CMF	9	4990.534	554.504	1.18	0.3034
CMF*RACE	18	9049.313	502.740	1.07	0.3771
Source	*df*	Type III *SS*	Mean Square	*F*	$p > F$
AGE	1	28637.582	28637.582	60.96	0.0001
STATURE	1	2163900.825	2163900.825	4606.27	0.0000
RACE	2	160631.566	80315.783	170.97	0.0001
CMF	9	4734.710	526.079	1.12	0.3450
CMF*RACE	18	9049.313	502.740	1.07	0.3771
FEMALE CROTCH HEIGHT					
Source	*df*	Sum of Squares	Mean Square	*F*	$p > F$
Model	19	2634336.091	138649.268	346.27	0.0000
Error	1616	647066.410	400.412		
Corrected Total	1635	3281402.501			
Source	*df*	Type I *SS*	Mean Square	*F*	$p > F$
AGE	1	2763.971	2763.971	6.90	0.0087
STATURE	1	2294094.259	2294094.259	5729.33	0.0000
RACE	2	329890.409	164945.204	411.94	0.0001
CMF	5	1620.820	324.164	0.81	0.5427
CMF*RACE	10	5966.632	596.663	1.49	0.1369
Source	*df*	Type III *SS*	Mean Square	*F*	$p > F$
AGE	1	28993.632	28993.632	72.41	0.0001
STATURE	1	2165605.053	2165605.053	5408.44	0.0000
RACE	2	206991.215	103495.608	258.47	0.0001
CMF	5	282.072	56.414	0.14	0.9827
CMF*RACE	10	5966.632	596.663	1.49	0.1369

Table 22. Comparative ANOVAs for Male and Female Anthropometric Database Values (Continued)

MALE FOOT LENGTH					
Source	*df*	Sum of Squares	Mean Square	*F*	*p* > *F*
Model	31	146146.5874	4714.406	63.12	0.0001
Error	1463	109278.3424	74.6947		
Corrected Total	1494	255424.9298			
Source	*df*	Type I *SS*	Mean Square	*F*	*p* > *F*
AGE	1	2.6240	2.6240	0.04	0.8514
STATURE	1	122992.0471	122992.0471	1646.60	0.0001
RACE	2	21876.3651	10938.1825	146.44	0.0001
CMF	9	389.6770	43.2974	0.58	0.8147
CMF*RACE	18	885.8742	49.2152	0.66	0.8535
Source	*df*	Type III *SS*	Mean Square	*F*	*p* > *F*
AGE	1	28.8606	28.8606	0.39	0.5343
STATURE	1	123502.8652	123502.8652	1653.44	0.0001
RACE	2	14653.8256	7326.9128	98.09	0.0001
CMF	9	509.7764	56.6418	0.76	0.6553
CMF*RACE	18	885.8742	49.2152	0.66	0.8535
FEMALE FOOT LENGTH					
Source	*df*	Sum of Squares	Mean Square	*F*	*p* > *F*
Model	19	140511.1569	7395.3240	119.43	0.0001
Error	1616	100069.3370	61.9241		
Corrected Total	1635	240580.4939			
Source	*df*	Type I *SS*	Mean Square	*F*	*p* > *F*
AGE	1	793.6160	793.6160	12.82	0.0004
STATURE	1	107703.1655	107703.1655	1739.28	0.0001
RACE	2	31301.4399	15650.7199	252.74	0.0001
CMF	5	274.5846	54.9169	0.89	0.4890
CMF*RACE	10	438.3510	43.8351	0.71	0.7178
Source	*df*	Type III *SS*	Mean Square	*F*	*p* > *F*
AGE	1	0.4432	0.4432	0.01	0.9326
STATURE	1	102924.0245	102924.0245	1662.10	0.0001
RACE	2	21441.0111	10720.5055	173.12	0.0001
CMF	5	261.7404	52.3481	0.85	0.5175
CMF*RACE	10	438.3510	43.8351	0.71	0.7178

Table 22. Comparative ANOVAs for Male and Female Anthropometric Database Values (Continued)

MALE HAND CIRCUMFERENCE					
Source	*df*	Sum of Squares	Mean Square	*F*	$p > F$
Model	31	34331.80692	1107.47764	15.69	0.0001
Error	1463	103258.37770	70.57989		
Corrected Total	1494	137590.18460			
Source	*df*	Type I *SS*	Mean Square	*F*	$p > F$
AGE	1	1927.78583	1927.78583	27.31	0.0001
STATURE	1	28450.45798	28450.45798	403.10	0.0001
RACE	2	792.96063	396.48032	5.62	0.0037
CMF	9	1538.87164	170.98574	2.42	0.0099
CMF*RACE	18	1621.73083	90.09616	1.28	0.1936
Source	*df*	Type III *SS*	Mean Square	*F*	$p > F$
AGE	1	1956.60912	1956.60912	27.72	0.0001
STATURE	1	26892.52295	26892.52295	381.02	0.0001
RACE	2	644.06136	322.03068	4.56	0.0106
CMF	9	1874.37963	208.26440	2.95	0.0018
CMF*RACE	18	1621.73083	90.09616	1.28	0.1936
FEMALE HAND CIRCUMFERENCE					
Source	*df*	Sum of Squares	Mean Square	*F*	$p > F$
Model	19	40219.09096	2116.79426	42.14	0.0001
Error	1616	81173.26295	50.23098		
Corrected Total	1635	121392.35390			
Source	*df*	Type I *SS*	Mean Square	*F*	$p > F$
AGE	1	5629.56247	5629.56247	112.07	0.0001
STATURE	1	28960.61992	28960.61992	576.55	0.0001
RACE	2	4404.86040	2202.43020	43.85	0.0001
CMF	5	765.80620	153.16124	3.05	0.0096
CMF*RACE	10	458.24198	45.8242	0.91	0.5208
Source	*df*	Type III *SS*	Mean Square	*F*	$p > F$
AGE	1	4040.88885	4040.88885	80.45	0.0001
STATURE	1	26917.67182	26917.67182	535.88	0.0001
RACE	2	2771.56197	1385.78099	27.59	0.0001
CMF	5	674.21315	134.84263	2.68	0.0201
CMF*RACE	10	458.24198	45.82420	0.91	0.5208

Table 22. Comparative ANOVAs for Male and Female Anthropometric Database Values (Continued)

MALE HEAD CIRCUMFERENCE					
Source	*df*	Sum of Squares	Mean Square	*F*	*p* > *F*
Model	31	50701.67938	1635.53804	8.02	0.0001
Error	1463	298230.3407	203.84849		
Corrected Total	1494	348932.0201			
Source	*df*	Type I *SS*	Mean Square	*F*	*p* > *F*
AGE	1	5211.83133	5211.83133	25.57	0.0001
STATURE	1	39218.15048	39218.15048	192.39	0.0001
RACE	2	684.14761	342.07380	1.68	0.1871
CMF	9	1909.80397	212.20044	1.04	0.4046
CMF*RACE	18	3677.74599	204.31922	1	0.4537
Source	*df*	Type III *SS*	Mean Square	*F*	*p* > *F*
AGE	1	5154.66827	5154.66827	25.29	0.0001
STATURE	1	36637.16093	36637.16093	179.73	0.0001
RACE	2	389.63290	194.81645	0.96	0.3848
CMF	9	2026.12041	225.12449	1.10	0.3562
CMF*RACE	18	3677.74599	204.31922	1.00	0.4537
FEMALE HEAD CIRCUMFERENCE					
Source	*df*	Sum of Squares	Mean Square	*F*	*p* > *F*
Model	19	66540.99282	3502.15752	18.56	0.0001
Error	1616	304910.81830	188.68244		
Corrected Total	1635	371451.81110			
Source	*df*	Type I *SS*	Mean Square	*F*	*p* > *F*
AGE	1	5666.79618	5666.79618	30.03	0.0001
STATURE	1	37141.43255	37141.43255	196.85	0.0001
RACE	2	21641.40250	10820.70125	57.35	0.0001
CMF	5	1004.50229	200.90046	1.06	0.3781
CMF*RACE	10	1086.85930	108.68593	0.58	0.8347
Source	*df*	Type III *SS*	Mean Square	*F*	*p* > *F*
AGE	1	2781.94005	2781.94005	14.74	0.0001
STATURE	1	35907.78682	35907.78682	190.31	0.0001
RACE	2	16249.86482	8124.93241	43.06	0.0001
CMF	5	542.95420	108.59084	0.58	0.7188
CMF*RACE	10	1086.85930	108.68593	0.58	0.8347

Table 22. Comparative ANOVAs for Male and Female Anthropometric Database Values (Continued)

MALE NECK CIRCUMFERENCE					
Source	*df*	Sum of Squares	Mean Square	*F*	$p > F$
Model	31	72210.23972	2329.36257	6.98	0.0001
Error	1463	488265.52350	333.74267		
Corrected Total	1494	560475.76320			
Source	*df*	Type I *SS*	Mean Square	*F*	$p > F$
AGE	1	11056.98903	11056.98903	33.13	0.0001
STATURE	1	51354.30690	51354.30690	153.87	0.0001
RACE	2	395.03572	197.51786	0.59	0.5534
CMF	9	3049.04291	338.78255	1.02	0.4254
CMF*RACE	18	6354.86517	353.04806	1.06	0.3905
Source	*df*	Type III *SS*	Mean Square	*F*	$p > F$
AGE	1	11225.60648	11225.60648	33.64	0.0001
STATURE	1	46896.28034	46896.28034	140.52	0.0001
RACE	2	1226.37714	613.18857	1.84	0.1596
CMF	9	4004.69277	444.96586	1.33	0.2145
CMF*RACE	18	6354.86517	353.04806	1.06	0.3905
FEMALE NECK CIRCUMFERENCE					
Source	*df*	Sum of Squares	Mean Square	*F*	$p > F$
Model	19	59163.62809	3113.87516	15.97	0.0001
Error	1616	315127.38110	195.00457		
Corrected Total	1635	374291.00920			
Source	*df*	Type I *SS*	Mean Square	*F*	$p > F$
AGE	1	11476.57361	11476.57361	58.85	0.0001
STATURE	1	39769.95373	39769.95373	203.94	0.0001
RACE	2	2857.46004	1428.73002	7.33	0.0007
CMF	5	1928.82769	385.76554	1.98	0.0790
CMF*RACE	10	3130.81301	313.08130	1.61	0.0992
Source	*df*	Type III *SS*	Mean Square	*F*	$p > F$
AGE	1	8663.61840	8663.61840	44.43	0.0001
STATURE	1	35889.99449	35889.99449	184.05	0.0001
RACE	2	779.90557	389.95279	2.00	0.1357
CMF	5	1357.47328	271.49466	1.39	0.2242
CMF*RACE	10	3130.81301	313.08130	1.61	0.0992

Table 22. Comparative ANOVAs for Male and Female Anthropometric Database Values (Continued)

MALE SITTING HEIGHT					
Source	*df*	Sum of Squares	Mean Square	*F*	$p > F$
Model	31	1406033.399	45355.916	115.94	0.000
Error	1463	572308.845	391.189		
Corrected Total	1494	1978342.243			
Source	*df*	Type I *SS*	Mean Square	*F*	$p > F$
AGE	1	412.185	412.185	1.05	0.3048
STATURE	1	1090083.287	1090083.287	2786.59	0.0000
RACE	2	302936.182	151468.091	387.20	0.0001
CMF	9	4427.812	491.979	1.26	0.2556
CMF*RACE	18	8173.934	454.107	1.16	0.2865
Source	*df*	Type III *SS*	Mean Square	*F*	$p > F$
AGE	1	2944.9923	2944.9923	7.53	0.0061
STATURE	1	976646.0388	976646.0388	2496.61	0.0000
RACE	2	188944.1745	94472.0873	241.50	0.0001
CMF	9	7559.4835	839.9426	2.15	0.0232
CMF*RACE	18	8173.9335	454.1074	1.16	0.2865
FEMALE SITTING HEIGHT					
Source	*df*	Squares	Square	*F*	$p > F$
Model	19	1409189.986	74167.894	219.54	0.0000
Error	1616	545932.314	337.829		
Corrected Total	1635	1955122.300			
Source	*df*	Type I *SS*	Mean Square	*F*	$p > F$
AGE	1	7360.213	7360.213	21.79	0.0001
STATURE	1	1075919.240	1075919.240	3184.80	0.0000
RACE	2	320135.364	160067.682	473.81	0.0001
CMF	5	375.800	75.160	0.22	0.9529
CMF*RACE	10	5399.369	539.937	1.60	0.1013
Source	*df*	Type III *SS*	Mean Square	*F*	$p > F$
AGE	1	3028.033	3028.033	8.96	0.0028
STATURE	1	1052022.668	1052022.668	3114.06	0.0000
RACE	2	200953.674	100476.837	297.42	0.0001
CMF	5	1143.630	228.726	0.68	0.6409
CMF*RACE	10	5399.369	539.937	1.60	0.1013

Table 22. Comparative ANOVAs for Male and Female Anthropometric Database Values (Continued)

MALE SPAN					
Source	*df*	Sum of Squares	Mean Square	*F*	$p > F$
Model	31	7496125.923	241810.514	141.39	0.000
Error	1463	2501998.746	1710.184		
Corrected Total	1494	9998124.669			
Source	*df*	Type I *SS*	Mean Square	*F*	$p > F$
AGE	1	155.173	155.173	0.09	0.7633
STATURE	1	6423369.825	6423369.825	3755.95	0.0000
RACE	2	1022381.166	511190.583	298.91	0.0001
CMF	9	26568.449	2952.050	1.73	0.0783
CMF*RACE	18	23651.310	1313.962	0.77	0.7395
Source	*df*	Type III *SS*	Mean Square	*F*	$p > F$
AGE	1	2614.780	2614.780	1.53	0.2165
STATURE	1	6312920.862	6312920.862	3691.37	0.0000
RACE	2	610220.588	305110.294	178.41	0.0001
CMF	9	26674.737	2963.860	1.73	0.0768
CMF*RACE	18	23651.310	1313.962	0.77	0.7395
FEMALE SPAN					
Source	*df*	Sum of Squares	Mean Square	*F*	$p > F$
Model	19	8221205.656	432695.035	275.59	0.0000
Error	1616	2537215.064	1570.059		
Corrected Total	1635	10758420.720			
Source	*df*	Type I *SS*	Mean Square	*F*	$p > F$
AGE	1	19713.822	19713.822	12.56	0.0004
STATURE	1	6577287.837	6577287.837	4189.20	0.0000
RACE	2	1597014.384	798507.192	508.58	0.0001
CMF	5	6591.935	1318.387	0.84	0.5214
CMF*RACE	10	20597.678	2059.768	1.31	0.2182
Source	*df*	Type III *SS*	Mean Square	*F*	$p > F$
AGE	1	5612.529	5612.529	3.57	0.0588
STATURE	1	6347465.296	6347465.296	4042.82	0.0000
RACE	2	986937.542	493468.771	314.30	0.0001
CMF	5	9803.108	1960.622	1.25	0.2838
CMF*RACE	10	20597.678	2059.768	1.31	0.2182

Table 22. Comparative ANOVAs for Male and Female Anthropometric Database Values (Continued)

MALE WAIST CIRCUMFERENCE					
Source	*df*	Sum of Squares	Mean Square	*F*	*p* > *F*
Model	31	2746327.319	88591.204	16.28	0.0001
Error	1463	7960636.219	5441.310		
Corrected Total	1494	10706963.540			
Source	*df*	Type I *SS*	Mean Square	*F*	*p* > *F*
AGE	1	1319309.801	1319309.801	242.46	0.0001
STATURE	1	705649.647	705649.647	129.68	0.0001
RACE	2	530137.500	265068.750	48.71	0.0001
CMF	9	49805.611	5533.957	1.02	0.4239
CMF*RACE	18	141424.760	7856.931	1.44	0.1020
Source	*df*	Type III *SS*	Mean Square	*F*	*p* > *F*
AGE	1	1345574.269	1345574.269	247.29	0.0001
STATURE	1	599501.678	599501.678	110.18	0.0001
RACE	2	419031.330	209515.665	38.50	0.0001
CMF	9	44580.699	4953.411	0.91	0.5152
CMF*RACE	18	141424.760	7856.931	1.44	0.1020
FEMALE WAIST CIRCUMFERENCE					
Source	*df*	Sum of Squares	Mean Square	*F*	*p* > *F*
Model	19	1659423.951	87338.103	15.15	0.0001
Error	1616	9316541.458	5765.187		
Corrected Total	1635	10975965.410			
Source	*df*	Type I *SS*	Mean Square	*F*	*p* > *F*
AGE	1	1190550.273	1190550.273	206.51	0.0001
STATURE	1	261330.178	261330.178	45.33	0.0001
RACE	2	138672.008	69336.004	12.03	0.0001
CMF	5	16933.221	3386.644	0.59	0.7097
CMF*RACE	10	51938.270	5193.827	0.90	0.5315
Source	*df*	Type III *SS*	Mean Square	*F*	*p* > *F*
AGE	1	1134124.746	1134124.746	196.72	0.0001
STATURE	1	280739.268	280739.268	48.70	0.0001
RACE	2	119869.418	59934.709	10.40	0.0001
CMF	5	33673.309	6734.662	1.17	0.3225
CMF*RACE	10	51938.270	5193.827	0.90	0.5315

Tables 25a and b and 26a and b show the results of the canonical discriminant analyses for the male and female data sets, carried out using SAS Proc CANDISC. Nine variates are derived for the men, and five are derived for the women. In both instances, however, only the first two canonical variates are statistically significant. These two variates account for 61.67% of the variation among CMFs for men and 76.46% of the variation among CMFs for women. Figure 5 displays the relationships among CMFs based upon these two variates.

Table 23. Tukey-Kramer Post-Hoc Comparison of Hand Circumference among Male CMFs[1]

	CMF 11	CMF 13	CMF 19	CMF 31	CMF 51	CMF 63	CMF 71	CMF 76	CMF 88	CMF 91
CMF 11										
CMF 13										
CMF 19										
CMF 31										
CMF 51										
CMF 63							*			
CMF 71						*			*	
CMF 76									*	
CMF 88							*	*		
CMF 91										

Table 24. Tukey-Kramer Post-Hoc Comparison of Chest Circumference among Female CMFs[9]

	CMF 31	CMF 63	CMF 71	CMF 76	CMF 88	CMF 91
CMF 31					*	
CMF 63						
CMF 71					*	
CMF 76					*	
CMF 88	*		*	*		
CMF 91						

[1]Paired comparisons significantly different at the .05 level are indicated by an asterisk(*).

Table 25a. Canonical Discriminant Analysis of Male CMFs

Canonical Variate	Canonical Correlation	Eigenvalue	Proportion	Cumulative Proportion	
1	0.217	0.0495	0.3382	0.3382	
2	0.198	0.0408	0.2785	0.6167	
3	0.124	0.0157	0.1075	0.7242	
4	0.116	0.0137	0.0934	0.8176	
5	0.101	0.0140	0.0710	0.8886	
6	0.091	0.0084	0.0575	0.9461	
7	0.071	0.0050	0.0344	0.9806	
8	0.052	0.0027	0.0182	0.9988	
9	0.013	0.0002	0.0012	1.0000	
Canonical Variate	Likelihood Ratio	Approximate *F*	Numerator *df*	Denominator *df*	$p >$ *F*
1	0.8659	1.8331	117	11022.35	0.0001
2	0.9087	1.4817	96	9939.74	0.0016
3	0.9458	1.0743	77	8846.26	0.3082
4	0.9606	0.9926	60	7738.28	0.4922
5	0.9738	0.8757	45	6610.08	0.7066
6	0.9839	0.7522	32	5452.19	0.8414
7	0.9922	0.5547	21	4247.44	0.9484
8	0.9972	0.3501	12	2960.00	0.9794
9	0.9998	0.0532	5	1481.00	0.9982

Table 25b. Canonical Discriminant Analysis of Male CMFs: Total Canonical Structure

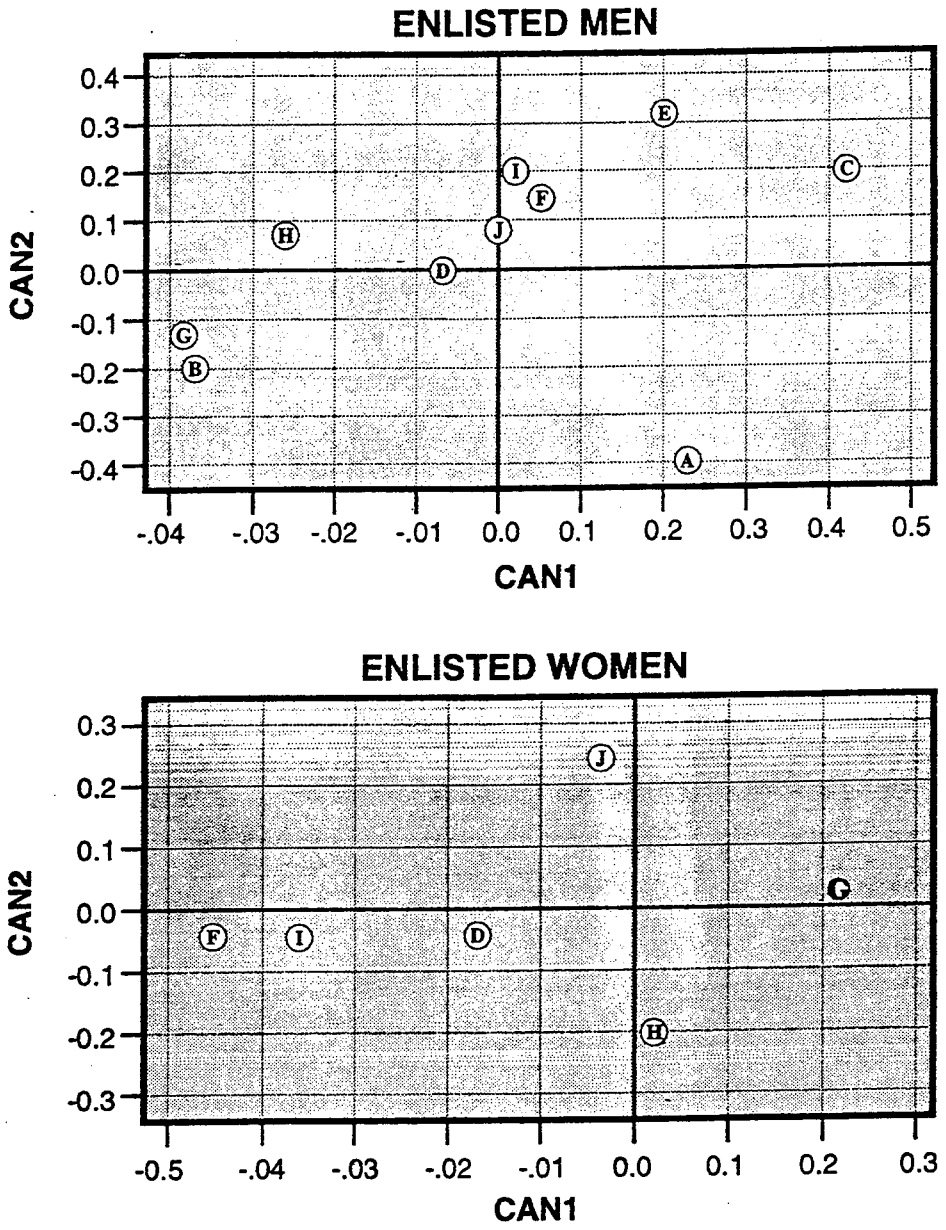
DIMENSIONS	CAN1	CAN2	CAN3	CAN4	CAN5	CAN6	CAN7	CAN8	CAN9
Stature	0.369425	-0.086136	-0.160281	-0.319898	-0.139700	0.586749	0.085914	-0.237449	0.053159
Weight	0.489446	-0.090135	-0.100395	-0.124289	-0.049959	0.114283	-0.119831	0.192323	0.377880
Biacromial Breadth	0.613388	-0.050705	-0.095187	0.134272	0.134016	0.120501	0.113512	-0.064472	-0.379023
Buttock Circumference	0.390390	-0.066050	-0.073290	-0.057484	0.037664	0.028578	0.116686	0.339639	0.477860
Chest Circumference	0.482267	-0.297741	-0.004449	0.012500	0.261168	0.063125	-0.169434	0.298272	0.333866
Crotch Height	0.161054	0.069423	0.208905	-0.235160	-0.018515	0.591182	-0.114445	-0.417532	-0.017756
Foot Length	0.121472	0.077102	-0.072210	-0.294435	0.112244	0.279101	-0.172095	-0.305553	0.242292
Head Circumference	0.099813	0.195613	-0.000260	-0.417641	-0.058882	0.264880	-0.183398	0.627284	-0.189141
Hand Circumference	0.285146	0.230373	-0.362792	-0.502805	0.287893	-0.075372	-0.083529	-0.198751	0.045136
Neck Circumference	0.313070	0.103901	0.079578	-0.019385	-0.114681	-0.146826	0.046222	0.123914	0.179705
Sitting Height	0.671879	0.021715	-0.318117	-0.344424	-0.197727	0.258070	0.268699	0.021080	0.128930
Span	0.206779	0.008559	-0.150590	-0.085120	0.049386	0.347631	-0.224915	-0.253028	-0.080434
Waist Circumference (O)	0.386768	0.028054	-0.204763	0.202542	0.069477	0.223195	-0.039091	0.378376	0.493892

Table 26a. Canonical Discriminant Analysis of Female CMFs

Canonical Variate	Canonical Correlation	Eigenvalue	Proportion	Cumulative Proportion	
1	0.208	0.0450	0.5163	0.5163	
2	0.146	0.0217	0.2483	0.7646	
3	0.100	0.0102	0.1169	0.8815	
4	0.086	0.0074	0.0847	0.9662	
5	0.054	0.0029	0.0338	1.0000	
Canonical Variate	Likelihood Ratio	Approximate *F*	Numerator *df*	Denominator *df*	$p >$ *F*
1	0.9177	2.1595	65	7650.31	0.0001
2	0.9590	1.4204	48	6238.60	0.0299
3	0.9798	1.0075	33	4773.52	0.4556
4	0.9898	0.8370	20	3242.00	0.6695
5	0.9971	0.5306	9	1622.00	0.8531

Table 26b. Canonical Discriminant Analysis of Females: Total Canonical Structure

DIMENSIONS	CAN1	CAN2	CAN3	CAN4	CAN5
Stature	-0.323492	-0.066661	0.293520	0.154788	-0.290605
Weight	-0.280120	-0.055599	0.630150	0.502284	0.155168
Biacromial Breadth	-0.033591	-0.116721	0.320217	-0.174088	-0.015603
Buttock Circumference	-0.055469	0.174511	0.714928	0.460865	0.291127
Chest Circumference	-0.395651	0.087399	0.561333	0.445534	0.259060
Crotch Height	-0.059643	-0.398817	0.128357	0.179794	-0.111105
Foot Length	0.164444	-0.364945	0.323714	0.214284	-0.115577
Head Circumference	0.161051	0.124710	0.317379	0.226271	-0.289635
Hand Circumference	-0.207283	-0.448434	0.588433	-0.012902	-0.313768
Neck Circumference	-0.293090	-0.086956	0.538258	-0.038286	0.272411
Sitting Height	-0.529168	0.306871	0.139159	0.108784	-0.262188
Span	0.086972	-0.425736	0.307676	0.202117	-0.309762
Waist Circumference (O)	-0.140756	0.247206	0.377861	0.437067	0.227122



KEY

SYMBOL	CMF #	OCCUPATION
A	CMF 11	INFANTRY
B	CMF 13	FIELD ARTILLERY
C	CMF 19	ARMOR
D	CMF 31	SIGNAL OPERATIONS
E	CMF 51	GENERAL ENGINEERING
F	CMF 63	MECHANICAL MAINTENANCE
G	CMF 71	ADMINISTRATION
H	CMF 76	SUPPLY and SERVICE
I	CMF 88	TRANSPORTATION
J	CMF 91	MEDICAL

Figure 3. Plots of CMF group centroids on the first and second canonical variables that discriminate among the CMFs.

Although some information may be gleaned from the clustering of CMFs seen in these plots, interpretations were more appropriately based upon the distances that separate CMFs. A fuller appreciation of these distances was found in the Mahalanobis D^2 distance matrix (see Tables 27 and 28), which is derived from a consideration of all the canonical variates. As shown in the tables, the calculations were performed including the anthropomorphic dimensions of Stature, Weight, Biacromial Breadth, Buttock Circumference, Chest Circumference, Crotch Height, Foot length, Head Circumference, Hand Circumference, Neck Circumference, Sitting Height, Span, and Waist Circumference (Omphalion). The highest mean D^2 identified the CMF that was most different from the other occupation groups based on the anthropometric measurements. Although the distances separating the CMFs were small, the results suggested that CMF 13 (Field Artillery) among men and CMF 88 (Transportation) among women were the most anthropometrically unique occupation groups employed in this study.

Table 27. Mahalanobis D^2 Distances among Male CMF Group Centroids

	CMF 11	CMF 13	CMF 19	CMF 31	CMF 51	CMF 63	CMF 71	CMF 76	CMF 88	CMF 91
CMF 11	.0000	.6798	.5527	.3583	.6723	.3294	.4997	.4698	.4007	.2654
CMF 13	.6798	.0000	1.1600	.5175	1.1363	.5545	.4407	.4811	.7146	.5991
CMF 19	.5527	1.1600	.0000	.4599	.4324	.3588	.8687	.6255	.3810	.3699
CMF 31	.3583	.5175	.4599	.0000	.4675	.2147	.2793	.1837	.1856	.1497
CMF 51	.6723	1.1363	.4324	.4675	.0000	.2341	.7548	.4592	.3814	.3930
CMF 63	.3294	.5545	.3588	.2147	.2341	.0000	.3375	.1988	.0952	.0682
CMF 71	.4997	.4407	.8687	.2793	.7548	.3375	.0000	.1522	.4469	.2256
CMF 76	.4698	.4811	.6255	.1837	.4592	.1988	.1522	.0000	.3215	.1325
CMF 88	.4007	.7146	.3810	.1856	.3814	.0952	.4469	.3215	.0000	.1462
CMF 91	.2654	.5991	.3699	.1497	.3930	.0682	.2256	.1325	.1462	.0000
Mean D^2	.4698	.6982	.5788	.3129	.5479	.2657	.4450	.3360	.3415	.2611

Table 28. Mahalanobis D^2 Distances among Female CMF Group Centroids

	CMF 31	CMF 63	CMF 71	CMF 76	CMF 88	CMF 91
CMF 31	0.0000	0.1389	0.1981	0.1696	0.2496	0.1875
CMF 63	0.1389	0.0000	0.4691	0.3151	0.2434	0.2995
CMF 71	0.1981	0.4691	0.0000	0.1198	0.4800	0.1628
CMF 76	0.1696	0.3151	0.1198	0.0000	0.3419	0.2211
CMF 88	0.2496	0.2434	0.4800	0.3419	0.0000	0.3344
CMF 91	0.1875	0.2995	0.1628	0.2211	0.3344	0.0000
Mean D^2	0.2396	0.2932	0.2860	0.2335	0.3299	0.2411

As with the body size and shape data, it is also important to determine if the anthropometric dimensions of each CMF differ from the observed values for the Army as a whole. This question was again addressed using the $SPSS_X$ *t*-test procedure to compare sample means for each CMF with the Army's anthropometric working data base. Tables 29 and 30 present the results of these comparisons. Among men, CMFs 71 (Administration) and 76 (Supply and Service) stood out as having anthropometric dimensions that differed significantly from the Army as a whole. Sample mean values for Chest Circumference and Sitting Height were significantly different from the Army value for both CMFs, while Biacromial Breadth and Waist Circumference were significant only within CMF 76. Among women, CMF 71 was significantly different for Chest Circumference and Sitting Height, whereas Sitting Height was also significant for CMF 76, and Chest Circumference was also significant for CMF 88. For both men and women, these CMFs have racial compositions that were widely divergent from the Army as a whole; generally they have a larger proportion of Black soldiers than White soldiers. Given that the ANOVA test suggested the importance of Race in deciding anthropometric differences among CMFs, these results should not be unexpected. Again, however, although these observed differences were statistically significant, their relative magnitudes were so small that they probably have little relevance to current clothing and equipment design.

In sum, for both men and women, the anthropometric values of CMFs were basically the same. Once again, Race stood out as the factor most associated with observed differences among occupation groups. Still, those differences that were found were very small, and thus are unlikely to be important to any clothing or equipment application.

4. CONCLUSIONS

This report has examined several critical areas of difference among Army occupation groups. In almost every instance, it is the demographic components (age, race, and sex) that were most strongly associated with observed differences. In other words, if one controls for age, race, and sex, the anthropometric measures of Army occupation groups are basically the same. This conclusion has a short term and a long term implication.

The short term implication speaks to the importance of anthropometric differences among occupation groups to current designs. The design significance of anthropometric difference can only be assessed based on the requirements of a particular piece of clothing or equipment. Yet, none of the statistically significant differences reported here were very large. Even when age and race compositions were not controlled for in the analyses, there were no extreme differences among the occupation groups studied here. Therefore, it is unlikely that anthropometric differences among occupation groups will have much impact on current designs of clothing and individual equipment.

The long term implication speaks to the importance of the demographic composition of occupation groups. Previous studies (Bradtmiller et al., 1985; Greiner and Gordon, 1990) have shown that future Army populations can be expected to have different demographic compositions, which will affect anthropometric distributions. This report found that the demographic components of race, age and sex are not randomly distributed among Army occupation groups. Therefore, the effects of demographic shifts within the Army population may be magnified within occupation groups. Thus, anthropometric differences that are not particularly relevant today may become

important differences in the future. Accounting for, and anticipating, these differences lies with the important task of monitoring and evaluating demographic changes in the Army and its occupational subgroups.

Table 29. Comparison of Male CMF Anthropometric Dimensions with the Entire Population of Army Men

BIACROMIAL BREADTH (mm)				
CMF	Mean	*t*	*n*	*p*
Army	397			
11	399	-1.70	249	0.090
13	391	2.23	47	0.026
19	400	-1.64	88	0.101
31	395	1.73	179	0.084
51	399	-0.57	45	0.568
63	398	0.22	283	0.825
71	393	2.53	138	0.011
76	393	2.92	199	0.004*
88	397	-0.31	121	0.758
91	396	0.31	146	0.756
BUTTOCK CIRCUMFERENCE (mm)				
CMF	Mean	*t*	*n*	*p*
Army	984			
11	987	-0.70	249	0.482
13	973	1.16	47	0.245
19	987	-0.48	88	0.631
31	979	0.95	179	0.344
51	983	0.04	45	0.968
63	983	0.15	283	0.880
71	972	2.06	138	0.039
76	971	2.64	199	0.008
88	981	0.51	121	0.611
91	981	0.54	146	0.590
CHEST CIRCUMFERENCE (mm)				
CMF	Mean	*t*	*n*	*p*
Army	991			
11	999	-1.70	249	0.089
13	970	2.03	47	0.043
19	990	0.22	88	0.828
31	983	1.51	179	0.131
51	979	1.18	45	0.238
63	985	1.48	283	0.140
71	974	2.82	138	0.005*
76	974	3.32	199	0.001*
88	985	0.85	121	0.396
91	988	0.64	146	0.522
CROTCH HEIGHT (mm)				
CMF	Mean	*t*	*n*	*p*
Army	837			
11	836	0.26	249	0.798
13	837	0.00	47	0.998
19	847	-1.87	88	0.062
31	837	0.04	179	0.970
51	828	1.27	45	0.205
63	836	0.26	283	0.791
71	837	0.15	138	0.879
76	833	1.09	199	0.274
88	844	-1.57	121	0.117
91	837	0.04	146	0.967

* Difference between CMF and Army population means are significant ($p < .05$, adjusted for 10 comparisons).

Table 29. Comparison of Male CMF Anthropometric Dimensions with the Entire Population of Army Men (Continued)

CMF	Mean	*t*	*n*	*p*
FOOT LENGTH (mm)				
Army	270			
11	270	-0.20	249	0.843
13	270	-0.22	47	0.827
19	271	-0.66	88	0.509
31	270	-0.04	179	0.965
51	269	0.56	45	0.575
63	270	-0.96	283	0.335
71	269	0.27	138	0.787
76	269	0.46	199	0.648
88	272	-1.86	121	0.063
91	270	-0.21	146	0.830
HAND CIRCUMFERENCE (mm)				
CMF	Mean	*t*	*n*	*p*
Army	214			
11	213	0.57	249	0.566
13	213	0.40	47	0.689
19	213	0.42	88	0.671
31	213	0.62	179	0.532
51	215	-0.53	45	0.599
63	215	-1.60	283	0.110
71	212	2.16	138	0.031
76	213	1.74	199	0.081
88	216	-2.29	121	0.022
91	213	0.40	146	0.688
HEAD CIRCUMFERENCE (mm)				
CMF	Mean	*t*	*n*	*p*
Army	568			
11	565	2.28	249	0.023
13	568	-0.21	47	0.837
19	568	0.00	88	0.999
31	567	0.31	179	0.754
51	565	1.04	45	0.300
63	568	0.06	283	0.955
71	565	1.84	138	0.066
76	565	2.30	199	0.022
88	568	0.03	121	0.975
91	568	-0.03	146	0.975
NECK CIRCUMFERENCE (mm)				
CMF	Mean	*t*	*n*	*p*
Army	380			
11	379	0.40	249	0.688
13	377	1.00	47	0.319
19	382	-0.98	88	0.329
31	379	0.50	179	0.615
51	381	-0.51	45	0.609
63	379	0.42	283	0.672
71	376	2.31	138	0.021
76	377	1.66	199	0.097
88	379	0.46	121	0.647
91	378	0.82	146	0.413

* Difference between CMF and Army population means are significant ($p < .05$, adjusted for 10 comparisons).

Table 29. Comparison of Male CMF Anthropometric Dimensions with the Entire Population of Army Men (Continued)

SITTING HEIGHT (mm)				
CMF	Mean	*t*	*n*	*p*
Army	914			
11	914	-0.38	249	0.704
13	910	0.78	47	0.435
19	920	-1.49	88	0.137
31	906	2.69	179	0.007
51	915	-0.12	45	0.903
63	915	-0.27	283	0.787
71	902	3.66	138	0.000*
76	901	4.93	199	0.000*
88	915	-0.27	121	0.785
91	909	1.54	146	0.123
SPAN (mm)				
CMF	Mean	*t*	*n*	*p*
Army	1823			
11	1826	-0.51	249	0.613
13	1819	0.31	47	0.754
19	1830	-0.82	88	0.410
31	1816	1.10	179	0.274
51	1815	0.66	45	0.508
63	1826	-0.47	283	0.635
71	1818	0.69	138	0.489
76	1818	0.88	199	0.380
88	1831	-1.09	121	0.277
91	1825	-0.25	146	0.806
WAIST CIRCUMFERENCE (mm)				
CMF	Mean	*t*	*n*	*p*
Army	862			
11	859	0.60	249	0.552
13	833	2.30	47	0.021
19	865	-0.31	88	0.756
31	845	2.64	179	0.008
51	856	0.48	45	0.628
63	859	0.66	283	0.506
71	844	2.48	138	0.013
76	843	2.97	199	0.003*
88	852	1.27	121	0.203
91	858	0.56	146	0.573

* Difference between CMF and Army population means are significant ($p < .05$, adjusted for 10 comparisons).

Table 30. Comparison of Female CMF Anthropometric Dimensions with the Entire Population of Army Women

BIACROMIAL BREADTH (mm)				
CMF	Mean	*t*	*n*	*p*
Army	363			
31	961	1.39	193	0.166
63	362	0.49	127	0.623
71	361	1.85	605	0.064
76	363	-0.30	296	0.761
88	362	0.42	82	0.677
91	362	1.01	333	0.312
BUTTOCK CIRCUMFERENCE (mm)				
CMF	Mean	*t*	*n*	*p*
Army	967			
31	958	1.99	193	0.047
63	955	2.09	127	0.037
71	961	2.15	605	0.031
76	965	0.38	296	0.702
88	979	-1.79	82	0.074
91	968	-0.37	333	0.715
CHEST CIRCUMFERENCE (mm)				
CMF	Mean	*t*	*n*	*p*
Army	907			
31	906	0.30	193	0.762
63	908	-0.20	127	0.843
71	899	2.78	605	0.006*
76	907	0.01	296	0.990
88	929	-3.00	82	0.003*
91	910	-0.72	333	0.474
CROTCH HEIGHT (mm)				
CMF	Mean	*t*	*n*	*p*
Army	771			
31	772	-0.24	193	0.810
63	773	-0.50	127	0.614
71	772	-0.11	605	0.913
76	775	-1.49	296	0.137
88	777	-1.17	82	0.241
91	767	1.52	333	0.129
FOOT LENGTH (mm)				
CMF	Mean	*t*	*n*	*p*
Army	244			
31	244	0.70	193	0.486
63	244	0.74	127	0.459
71	245	-1.09	605	0.278
76	246	-1.93	296	0.053
88	245	-0.79	82	0.428
91	243	1.25	333	0.210
HAND CIRCUMFERENCE (mm)				
CMF	Mean	*t*	*n*	*p*
Army	186			
31	186	0.86	193	0.392
63	187	-1.20	127	0.229
71	186	1.28	605	0.202
76	188	-2.59	296	0.010
88	188	-1.73	82	0.084
91	186	1.20	333	0.229

* Difference between CMF and Army population means are significant ($p < .05$, adjusted for 6 comparisons).

Table 30. Comparison of Female CMF Anthropometric Dimensions with the Entire Population of Army Women (Continued)

HEAD CIRCUMFERENCE (mm)				
CMF	Mean	*t*	*n*	*p*
Army	546			
31	544	1.73	193	0.085
63	545	1.11	127	0.265
71	547	-0.61	605	0.541
76	546	0.13	296	0.901
88	547	-0.46	82	0.645
91	547	-0.38	333	0.704
NECK CIRCUMFERENCE (mm)				
CMF	Mean	*t*	*n*	*p*
Army	316			
31	316	-0.22	193	0.824
63	317	-0.87	127	0.386
71	315	1.57	605	0.115
76	317	-1.83	296	0.067
88	319	-1.77	82	0.077
91	317	-0.97	333	0.333
SITTING HEIGHT (mm)				
CMF	Mean	*t*	*n*	*p*
Army	852			
31	848	1.50	193	0.134
63	855	-0.89	127	0.373
71	843	5.45	605	0.000*
76	845	3.37	296	0.001*
88	856	-0.93	82	0.354
91	851	0.59	333	0.554
SPAN (mm)				
CMF	Mean	*t*	*n*	*p*
Army	1672			
31	1668	0.62	193	0.537
63	1672	-0.01	127	0.989
71	1676	-0.99	605	0.323
76	1682	-2.09	296	0.037
88	1682	-1.10	82	0.270
91	1665	1.43	333	0.151
WAIST CIRCUMFERENCE (mm)				
CMF	Mean	*t*	*n*	*p*
Army	792			
31	788	0.70	193	0.481
63	785	0.91	127	0.363
71	786	1.45	605	0.148
76	788	0.84	296	0.401
88	809	-1.80	82	0.071
91	796	-0.94	333	0.346

* Difference between CMF and Army population means are significant ($p < .05$) adjusted for 6 comparisons).

5. REFERENCES

Army Regulation 611-201 (1986) Enlisted Career Management Fields and Military Occupational Specialties. Department of the Army: Washington, DC.

Barth, F (1969) Ethnic Groups and Boundaries. Little Brown & Co.: Boston.

Bradtmiller, B, J Ratnaparkhi, and I Tebbetts (1985) Demographic and Anthropometric Assessment of US. Army Anthropometric Data Base. Technical Report No. NATICK/TR-86/004. US Army Natick Research, Development and Engineering Center, NATICK, MA.

Brues, AM (1977) People and Races. Macmillan Publishing Co.: New York.

Bullen, AK (1948) Vocational Incidence of Seven Body Types in 547 US. Army Women. Contract Report W44-109-qm-1078. Department of Anthropology, Harvard University: Cambridge, MA.

Chumlea, WC, PJ Garry, WC Hunt, and RL Rhyne (1988) Distributions of Serial Changes in Stature and Weight in a Healthy Elderly Population. Human Biology 60:917-925.

Cline, MG, KE Meredith, JT Boyer, and B Burrows (1989) Decline of Height with Age in Adults in a General Population Sample: Estimating Maximum Height and Distinguishing Birth Cohort Effects from Actual Loss of Stature with Aging. Human Biology 61:415-425.

Gordon, CC, and N Bell (1991) Problems of Racial and Ethnic Group Self-Identification and Classification. Paper Presented at the 90th Annual Meeting of the American Anthropological Association.

Gordon, CC, T Churchill, CE Clauser, B Bradtmiller, JT McConville, I Tebbetts, and RA Walker (1989) 1988 Anthropometric Survey of US Army Personnel: Methods and Summary Statistics. Technical Report No. NATICK/TR-89/044. US Army Natick Research, Development and Engineering Center: Natick, MA.

Greiner, TM and CC Gordon (1990) An Assessment of Long-Term Changes in Anthropometric Dimensions: Secular Trends of US Army Males. Technical Report No. NATICK/TR-91/006. US Army Natick Research, Development and Engineering Center: Natick, MA.

Greiner, TM and CC Gordon (1992) Secular Trends of 22 Body Dimensions in Four Racial/Cultural Groups of American Males. American Journal of Human Biology 4:235-246.

Hooton, EA (1948) Body Build in Relation to Military Function in a Sample of the United States Army. Contract Report No. W44-109-qm-1078. Department of Anthropology, Harvard University: Cambridge, MA.

Hooton, EA (1959) Body Build in a Sample of the United States Army. Part I: Body Build in Relation to Military Function. Technical Report EP-102. Headquarters Quartermaster Research & Engineering Command: Natick, MA.

Lasker, GW, and CGN Mascie-Taylor (1989) Effects of Social Class Differences and Social Mobility on Growth in Height, Weight and Body Mass Index in a British Cohort. Annals of Human Biology 16:1-8.

Molnar, S (1983) Human Variation: Race, Types, and Ethnic Groups. 2nd edition. Prentice-Hall, Inc.: Englewood Cliffs, NJ.

PERSINSCOM(1988) Enlisted Demographics Magnetic Tape reel ID Numbers AAB447 (Female), AAB280 (Male) HQ PERSINSCOM ASQNI-ASE-S Alexandria, VA

Randall, Francis E. (1949) Age Changes in Young Adult Army Males. Human Biology 21(3):187-198.

Reyment, RA, RE Blackith and NA Campbell (1984) Multivariate Morphometrics. 2nd edition. Academic Press: New York.

SAS Institute, Inc. (1988) SAS/STAT User's Guide, Release 6.03 Edition. SAS Institute, Inc.: Cary, NC

Sokal, RR and FJ Rohlf (1981) Biometry: The Principles and Practice of Statistics in Biological Research. 2nd edition. WH Freeman and Company: San Francisco.

Vogel, JA, JE Wright, JF Patton, J Dawson, and MP Eschenback (1980) A System for Establishing Occupationally-Related Gender-Free Physical Fitness Standards. Technical Report No. T 5/80. US Army Research Institute of Environmental Medicine: Natick, MA.

APPENDIX A

Descriptions of Anthropometric Dimensions*

Measures of Body Size and Shape

1. STATURE: Vertical distance from standing surface to the top of the head.

2. WEIGHT: Nude body weight recorded in kilograms.

3. BODY MASS INDEX: An expression of body size calculated as WEIGHT in kilograms divided by STATURE in meters squared.

4. ATTENUATION INDEX: An expression of body shape calculated as STATURE in mm divided by the cubed root of WEIGHT in grams.

Measures of Body Components

5. BIACROMIAL BREADTH: Horizontal distance between the acromion landmarks.

6. BUTTOCK CIRCUMFERENCE: Horizontal circumference of the trunk measured at the level of the maximum protrusion of the right buttock.

7. CHEST CIRCUMFERENCE: Horizontal circumference of the trunk measured at the level of right nipple on men and the right bust point on women.

8. CROTCH HEIGHT: Vertical distance between the standing surface and the crotch.

9. FOOT LENGTH: Distance between the tip of the longest toe and the back of the heel of the standing foot.

10. HAND CIRCUMFERENCE: Circumference of the hand measured at the level of the metacarpal landmarks.

11. HEAD CIRCUMFERENCE: Maximum circumference of the head measured above the ears and the eyebrow ridges.

*All dimensions measure the right side of the body and are recorded in millimeters, unless noted otherwise. More complete descriptions of these dimensions, and the methods used to collect them, can be found in Gordon et al. (1989)

12. NECK CIRCUMFERENCE: Circumference of the neck at the infra thyroid landmark.

13. SITTING HEIGHT: Vertical distance between the sitting surface and the top of the head.

14. SPAN: Distance between the tip of the third fingers when the arms are stretched out horizontally.

15. WAIST CIRCUMFERENCE: Horizontal circumference of the torso measured at the level of the omphalion landmark.